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CHEMICAL ESSAYS.

BY

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NOtwithſtanding what I had ſaid, in the concluſion of the Preface to the Fourth Volume of my Chemical Eſſays, concerning the little likelihood of the Tracts there mentioned being acceptable to many readers, my Bookſeller has deſired leave to publiſh them. He has formed an expectation, that the purchaſers of the Chemical Eſſays will not be diſpleaſed at having an opportunity of poſſeſſing all that remains of what I have ever written on chemical ſubjects. Great improvements have been made in many branches of chemiſtry ſince the *Inſtitutiones Metallurgicæ*, and the Plan of Chemical Lectures were firſt printed, but I have no inclination to reviſe them; they will be candidly read with a reference to the time when they were compoſed. I do not recollect what motive induced me to write the Metallurgic Inſtitutes in Latin, unleſs it was the vanity of thinking, that when I had treated the other parts of Chemiſtry in the ſame manner, the work might ſtand a chance of finding its way into foreign countries. I had written ſeveral chapters *de Aere communi-fixo-inflammabili*; *de Igne*; *de Aqua*; *de Terra calcaria, vitreſcibili*, &c. much about the period in which the Metallurgic Inſtitutes were finiſhed: but my attention being ſoon after called to other purſuits, I gave up the deſign which I had formed, of expreſſing in a connected ſeries of propoſitions what was then ſcientifically known in Chemiſtry; and what I had written, with this view, ſhared the fate of my other chemical manuſcripts when I determined laſt year to quit this favourite ſtudy.

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ESSAY I.

Obſervations on the Sulphur Wells at HARROGATE, *made in July and Auguſt*, 1785.

IN 1733, when Doctor SHORT firſt publiſhed his Treatiſe on Mineral Waters, there were only three ſulphur wells at Harrogate; there are now four. I made ſome inquiry reſpecting the time and occaſion of making the fourth well, and received the following account from an old man, who was himſelf principally concerned in the tranſaction. About forty years ago, a perſon who, by leaſe from the Earl of *Burlington*, had acquired a right of ſearching for minerals in the foreſt of Knareſborough, made a ſhew as if he had a real intention of digging for coal, on the very ſpot where the three ſulphur wells were ſituated. This attempt alarmed the apprehenſions of the inn-keepers and others at Harrogate, who were intereſted in the preſervation of the wells: they gave him what legal oppoſition they could, and all the illegal that they durſt. At length, for the ſum of one hundred pounds, which they raiſed amongſt themſelves, the diſpute was compromiſed, and the deſign real or pretended of digging for coal was abandoned. Sulphur water, however, had riſen up where he had begun to dig. They incloſed the place with a little ſtone edifice, and putting down a baſon, made a fourth well. By a clauſe in the act of parliament for incloſing Knareſborough Foreſt, paſſed in 1770, it is rendered unlawful for any perſon whatever to ſink any pit, or dig any quarry or mine, whereby the medicinal ſprings or waters at Harrogate may be damaged or polluted; ſo that no attempts of the kind above-mentioned need be apprehended in future.

This fourth well is that which is neareſt to one of the barns of the Crown-Inn, being about ten yards diſtant from it. In digging, a few years ſince, the foundation of that barn, they met with ſulphur water in ſeveral places. At a very little diſtance from the four wells there are two others of the ſame kind; one in the yard of the Half-Moon-Inn, diſcovered

covered in digging for common water in 1783, and another which breaks out on the ſide of the rivulet below that Inn. On the banks of that rivulet I ſaw ſeveral other ſulphureous ſprings: they are eaſily diſtinguiſhed by the blackneſs of the earth over which they flow.

On the declivity of a hill, about a quarter of a mile to the weſt of the ſulphur wells at Harrogate, there is a bog which has been formed by the rotting of wood: the earth of the rotten wood is in ſome places four feet in thickneſs, and there is a ſtratum conſiſting of clay, and ſmall looſe decaying ſand-ſtones, every where under it. The hill above is of grit-ſtone. In this bog there are four more ſulphur wells; one at the top, near the rails which ſeparate the bog from the Common; and three at the bottom, though one of theſe, ſtrictly ſpeaking, is not in the bog, but at the ſide of it in the ſtratum on which the bog is ſituated, and at the diſtance of a yard or two from a rivulet of freſh water, which runs from thence to Low Harrogate, paſſing cloſe to the ſide but above the level of the ſulphur wells of that place. On the other ſide of the hill, above the bog, and to the weſt of it, there is another ſulphur well on the ſide of a brook; and it has been thought that the wells both at Harrogate and in the bog are ſupplied from this well. In a low ground, between High Harrogate and Knareſborough, there is a ſulphur well; another to the north of it in Bilton Park, at about the diſtance of a mile; and another to the ſouth of it, at a leſs diſtance, was diſcovered this year in digging for common water by a perſon of the name of *Richardſon*; and, laſtly, there is another at a place called Hookſtone Crag: none of theſe laſt-mentioned wells are above two miles diſtant from High Harrogate; and by an accurate ſearch a great many more might, probably, be diſcovered in the neighbourhood.

It is not unuſual to dig within a few yards of any of theſe ſulphur wells, and to meet with water which is not ſulphureous. I ordered a well to be dug in the fore-mentioned bog, ſixteen yards to the ſouth of the ſulphur well which is near the rails, and to the ſame depth with it; the water with which it was preſently filled was chalybeate, but in no degree ſulphureous. I had another well dug, at about thirty yards diſtance from the three ſulphur wells which are ſituated at the lower extremity of the bog; this well, by the declivity of the ground, was ten or twelve feet below their level, but its water was not ſulphureous. From the firſt well which I dug, it is evident, that every part of the bog does not yield ſulphur water; and from the ſecond, which was ſunk into the clay, it is clear that every part of the ſtratum on which the bog is placed does not yield it, though one of the wells is ſituated in it.

The ſulphur wells at Harrogate are a great many feet below the level of thoſe in the bog; but they communicate with them, if we may rely on what Doctor *Short* has told us— "That about the beginning of this century, when the concourſe of people was very great to the Spaw at Harrogate, one *Robert Ward*, an old man, made a baſon in the clay under the moſs of a bog where the ſtrongeſt and briſkeſt of theſe ſulphur ſprings riſe, and gathered half an hogſhead of water at a time for the uſe of the poor; but when he laded this he almoſt dried the three ſulphur wells at the village, whence it is evident, that all have the ſame origin and communicate with one another." By converſing with ſome of the oldeſt and moſt intelligent people at Harrogate, I could not find that they entertained any opinion of the water at the bog having a communication with that at the Spaw. This circumſtance might eaſily be aſcertained; and, if the fact ſhould be contrary to what Doctor *Short* ſuppoſed, the wells at the bog ought to be covered from the weather as thoſe at the village are; they would by this mean yield great plenty of water for the baths which are wanted by invalids, and which are often very ſcantily ſupplied by the wells at Harrogate, notwithſtanding the attention which is uſed in preſerving the water which ſprings at the four wells, by emptying them as often as they become full during both the day and night time. And indeed it is ſurpriſing, that the well on the ſide of the rivulet below the Half-Moon-Inn, which is ſo well ſituated for the purpoſe, has never been incloſed for the furniſhing ſulphureous water for the baths. The preſent mode of carrying the water in caſks to the ſeveral houſes where the perſons lodge who want to bathe in it, is very troubleſome, and the water thereby loſes of its virtue. Some of the wells about the village, that for inſtance which has been diſcovered at the Half-Moon-Inn, the water of which, I believe, ſprings from a different ſource from that which ſupplies the four ſulphur wells, ſhould be either enlarged to a greater horizontal breadth, or ſunk to a greater depth, in order to try, by one or both of theſe ways, whether the quantity and ſtrength of the water might not be increaſed; and if that ſhould, as it probably would be the caſe, one or more baths might be erected after the manner of thoſe at Buxton and other places; or, by proper additional buildings, warm bathing in ſulphureous water might be practiſed, as is done in common water in the bagnios in London. The ſaltneſs of the ſulphureous water, if that ſhould be thought uſeful, might eaſily be made even greater than that of ſea water, by adding a quarter of a pound of common ſalt to every gallon of the water uſed in forming a bath. The waters at Harrogate, though they have long been very beneficial, have not yet been rendered ſo uſeful to mankind, as an intelligent and enterpriſing perſon might make them. The alternate ſtrata of ſand, ſtone, and ſhale, which compoſe the lower hills near the wells at Harrogate, dip very much, as may be ſeen in a ſtone quarry about two hundred yards from the wells; and the ſame circumſtance may be obſerved in dry weather, in following the bottom of the brook from the village up to the bog; and hence, if there be a communication between the waters of the bog and of the village, as Doctor SHORT aſſerts, it is probable, that the ſame ſtratum of ſhale which is ſeen at the bottom of the wells at the village, breaks out again at the bog above the village, and that the water finds its way from the bog to the village through the crevices of that ſtratum.

After having obſerved, as carefully as I could, the number and ſituation of the ſulphur wells about Harrogate, I took notice of the temperature of the four at the village. In the month of June, 1780, when the thermometer in the ſhade was 72°, and the pump water at the Granby-Inn, the well of which is fifty feet deep, was 48°, the ſtrongeſt of the ſulphur wells, being that of which invalids uſually drink, was 50°. On the 29th of July in this year, after the earth had been parched with drought for many months, the heat of the ſtrongeſt well was 54°; the water of the Granby pump was on the ſame day 48°, and the heat of the air in the ſhade 76°. Doctor Walker, who has lately written a treatiſe on Harrogate water, ſays, that the heat of this ſpring was 48°, when that of an adjoining rivulet was 53°. And I have little doubt in believing, that if the experiment was made in cold weather, the temperature of the ſame well would be found to be ſeveral degrees below 48. This variation of temperature in the ſulphur water indicates its ſpringing from no great depth below the ſurface of the earth; or at leaſt it indicates its having run for a conſiderable diſtance in a channel ſo near to the ſurface of the earth, as to participate of the changes of temperature, to which that is liable from the action of the ſun. But the heat of the ſulphur water is not only variable in the ſame well, at different times, but it is not the ſame in all the wells at the ſame time. If we call the ſtrongeſt well the firſt, and reckon the reſt in order, going to the right, the third well, which is reckoned the next ſtrongeſt, was 57° hot when the firſt well was 54°. In ſupport of the conjecture that the ſulphur water of the ſtrongeſt well would in a cold ſeaſon make the thermometer ſink below 48°, which is the conſtant temperature of ſprings ſituated at a great depth in the earth in this country, it may be obſerved, that though the firſt and the third well are never frozen, yet the ſecond and fourth well are frozen in ſevere weather. When the ſecond and the fourth well are covered with ice, it is probable, that the firſt and the third have a temperature far below 48°; but that the ſea ſalt, which is more abundant in them than in the other two wells, and which of all ſalts reſiſts moſt powerfully the congelation of the water in which it is diſſolved, preſerves them from being frozen in the coldeſt ſeaſons incident to our climate.

As the temperature of theſe four wells is not the ſame in all of them at the ſame time, nor invariable in any of them, ſo neither does there ſeem to be any uniformity or conſtancy in them, with reſpect to the quantity of ſalt which they contain. The ſalt with which they are all impregnated is of the ſame kind in all, and it is almoſt wholly common ſalt; and though the quantity contained in a definitive portion of any one of the wells is not, I think, preciſely the ſame at all ſeaſons of the year, yet the limits within which it varies are not, I apprehend, very great. A method is mentioned in the LXth volume of the Philoſophical Tranſactions, of eſtimating the quantity of common ſalt diſſolved in water, by taking the ſpecific gravity of the water: this method is not to be relied on, when any conſiderable portion of any other kind of ſalt is diſſolved along with the ſea ſalt; but it is accurate enough to give a good notion of the quantity contained in the different wells at Harrogate. On the 13th of Auguſt, after ſeveral days of rainy weather, I took the ſpecific gravities of the four ſulphur wells at the village, the drinking well being the firſt.—Rain water 1.000; firſt well 1.009; ſecond well 1.002; third well 1.007; fourth well 1.002. By comparing theſe ſpecific gravities with the table which is given in the LXth volume of the Tranſactions, it may be gathered, that the water of the firſt well contained $\frac{1}{72}$ of its weight of common ſalt; that of the ſecond and fourth, $\frac{1}{256}$; and that of the third, $\frac{1}{84}$. After four days more heavy rain I tried the ſtrongeſt well again, and found its ſpecific gravity to be 1.008. It is worthy of obſervation, that the water, as it ſprings into the firſt and third well, is quite tranſparent, but uſually of a pearl colour in the ſecond and fourth, ſimilar in appearance to the water of the firſt or third well after it has been expoſed a few hours to the air; hence it is probable, that the external air has acceſs to the water of the ſecond and fourth well before it ſprings up into the baſon. A great many authors have publiſhed accounts of the quantity of common ſalt contained in a gallon of the water of the ſtrongeſt well; they differ ſomewhat from each other, ſome making it more, others leſs, than two ounces. Theſe diverſities proceed either from the different care and ſkill uſed in conducting the experiment; or from a real difference in the quantity of ſalt with which the water is impregnated at different ſeaſons of the year. The medium quantity of ſalt contained in a gallon falls ſhort of, I think, rather than exceeds two ounces. The ſea water at Scarborough contains about twice as much ſalt as is found in the ſtrongeſt ſulphur well at Harrogate. The ſulphur wells at the bog are commonly ſaid to be ſulphureous, but not ſaline. This, however, is a miſtake; they contain ſalt, and ſalt of the ſame kind as the wells at the village. I could not diſtinguiſh the kind of ſalt by the method in which I had eſtimated the quantity contained in the ſulphur wells; I therefore evaporated a gallon of the water of the well in the bog which is near the rails, and obtained a full ounce of common ſalt, of a browniſh colour: the colour would have gone off by calcination. In what degree the medicinal powers of Harrogate water depend on its ſulphureous, and in what degree on its ſaline impregnation, are queſtions which I meddle not with: I would only juſt obſerve on this head, that any ſtrong ſulphureous water, ſuch as that of Keddleſtone in Derbyſhire, or of Shap in Weſtmoreland, which naturally contains little or no ſea ſalt, may be rendered ſimilar to Harrogate water, by diſſolving in it a proper proportion of common ſalt. The four ſulphur wells at Harrogate are very near to each other; they might all be included within the circumference of a circle of ſeven or eight yards in diameter; yet, from what has been ſaid it is evident, that they have not all either the ſame temperature, or the ſame quantity of ſaline impregnation. This diverſity of quality, in wells which have a proximity of ſituation, is no uncommon phænomenon; and though at the firſt view it ſeems to be ſurpriſing, yet it ceaſes to be ſo on reflection: for the waters which feed wells ſo circumſtanced, may flow through ſtrata of different qualities ſituated at different depths, though in the ſame direction; or through ſtrata placed both at different depths, and in different directions; and that this is the caſe at Harrogate is probable enough, there being hills on every ſide of the hollow in which the village is placed.

With reſpect to the ſulphureous impregnation of theſe waters, I made the following obſervations.

The inſide of the baſon, into which the water of the ſtrongeſt well riſes, is covered with a whitiſh pellicle, which may be eaſily ſcraped off from the grit-ſtone of which the baſon is made. I obſerved, in the year 1780, that this pellicle on a hot iron burned with the flame and ſmell of ſulphur. I this year repeated the experiment with the ſame ſucceſs; the ſubſtance ſhould be gently dried before it is put on the iron. I would further obſerve, that the ſulphur is but a ſmall part of the ſubſtance which is ſcraped off. That I might be certain of the poſſibility of obtaining true palpable ſulphur from what is ſcraped off from the baſon, and at the ſame time give ſome gueſs at the quantity of ſulphur contained in it, I took three or four ounces of it, and having waſhed it well, and dried it thoroughly by a gentle heat, I put two ounces into a clean glaſs retort, and ſublimed from it about two or three grains of yellow ſulphur. This ſulphur, which ſtuck to the neck of the retort, had an oily appearance; and the retort, when opened, had not only the ſmell of the volatile ſulphureous acid, which uſually accompanies the ſublimation of ſulphur, but it had alſo the ſtrong empyreumatic ſmell which peculiarly appertains to burnt oils; and it retained this ſmell for ſeveral days. It has been remarked before, that the ſalt ſeparable from the ſulphur water was of a browniſh colour; and others, who have analyſed this water, have met with a brown ſubſtance, which they knew not what to make of; both which appearances may be attributed to the oil, the exiſtence of which was rendered ſo manifeſt by the ſublimation here mentioned. I will not trouble the Society with any conjectures concerning the origin of this oil, or the medium of its combination with water; the diſcovery of it gave me ſome pleaſure, as it ſeemed to add a degree of probability to what I had ſaid concerning the nature of the air with which, in one of my Chemical Eſſays, I had ſuppoſed Harrogate water to be impregnated. I will again take the liberty of repeating the query which I there propoſed. "Does this air, and the inflammable air ſeparable from ſome metallic ſubſtances, conſiſt of *oleaginous* particles in an elaſtic ſtate?" When I ventured to conjecture, in the Eſſay alluded to, that ſulphureous waters received their impregnation from air of a particular kind, I did not know that Profeſſor *Bergman* had advanced the ſame opinion, and denominated that ſpecies of air, Hepatic Air. I have ſince then ſeen his works, and very readily give up to him not only the priority of the diſcovery, but the merit of proſecuting it. And though what he has ſaid concerning the manner of precipitating ſulphur from theſe waters can leave no doubt in the mind of any chemiſt concerning the actual exiſtence of ſulphur in them;

yet I will proceed to the mention of ſome other obvious experiments on the Harrogate water, in ſupport of the ſame doctrine.

Knowing that, in the baths of Aix-la-Chapelle, ſulphur is found ſticking to the ſides and top of the channel in which the ſulphureous water is conveyed, I examined with great attention the ſides of the little ſtone building which is raiſed over the baſon of the ſtrongeſt well, and ſaw them in ſome places of a yellowiſh colour: this I thought proceeded from a ſpecies of yellow moſs, commonly found on grit-ſtone: I collected, however, what I could of it by bruſhing the ſides of the building, at the diſtance of three or four feet from the water in the baſon: on putting what I had bruſhed off on a hot iron, I found that it conſiſted principally of particles of grit-ſtone, evidently however mixed with particles of ſulphur.

Much of the ſulphureous water is uſed for baths at Harrogate; and for that purpoſe all the four wells are frequently emptied into large tubs containing many gallons apiece; theſe conſtantly ſtand at the wells, and the caſks, in which the water is carried to the ſeveral houſes, are filled from them. On examining the inſides of theſe tubs, I found them covered, as if painted, with a whitiſh pellicle. I ſcraped off a part of this pellicle: it was no longer ſoluble in water; but, being put on a hot iron, it appeared to conſiſt almoſt wholly of ſulphur. Some of theſe tubs have been in uſe many years, and the adhering cruſt is thick in proportion to the time they have been applied to the purpoſe; but the ſulphur pellicle was ſufficiently obſervable on one which was new in the beginning of this ſeaſon. The water when it is firſt put into theſe tubs is tranſparent; when it has been expoſed to the air for a few hours, it becomes milky; and, where the quantity is large, a white cloud may be ſeen ſlowly precipitating itſelf to the bottom. This white precipitate conſiſts partly, I am not certain that it conſiſts wholly, of ſulphur; and the ſulphur is as really contained in the waters denominated ſulphureous, as iron is contained in certain ſorts of chalybeate waters; in the one caſe the iron is rendered ſoluble in water by its being united to fixed air, or ſome other volatile principle; and in the other ſulphur is rendered ſoluble in water by its being united to fixed air, or ſome other volatile principle: neither iron nor ſulphur are of themſelves ſoluble in water, but each of them, being reduced into the form of a ſalt by an union with ſome other ſubſtances, becomes ſoluble in water, and remains diſſolved in it, till that other ſubſtance either eſcapes into the air, or becómes combined with ſome other body.

About forty years ago, they took up the baſon of the third well, and a credible perſon, who was himſelf preſent at the operation, informed me, that in all the crevices of the ſtone on which the baſon reſted, there were layers of pure yellow ſulphur. This I can well believe, for I ordered a piece of ſhale to be broken off from the bottom of the fourth well; it was ſplit, as ſhale generally is, into ſeveral thin pieces, and was covered with a whitiſh cruſt. Being laid on a hot iron, in a dark room, it cracked very much, and exhibited a blue flame and ſulphureous ſmell.

If the water happens to ſtand a few days in any of the wells, without being diſturbed, there is found at the bottom a black ſediment; this black ſediment alſo marks the courſe of the water which flows from the well, and it may be eſteemed characteriſtic of a ſulphur water. The ſurface of the water alſo, when it is not ſtirred for ſome time, is covered with a whitiſh ſcum. Doctor *Short* had long ago obſerved, that both the black ſediment, and the white ſcum, gave clear indications, on a hot iron, of their containing ſulphur: I know not whence it has come that his accuracy has been queſtioned in this point; certain I am, that on the repetition of his experiments I found them true. The white ſcum alſo, which is found ſticking on the graſs over which the water flows, being gently dried, burns with the flame and ſmell of ſulphur. From what has been ſaid it is clear, that ſulphur is found at Harrogate, ſticking to the baſon into which the water ſprings; ſublimed upon the ſtones which compoſe the edifice ſurrounding the well; adhering to the ſides of the tubs in which the water ſtands; ſubſiding to the bottom of the channel in which the water runs; and covering the ſurface of the earth, and of the blades of graſs, over which it flows. It is unneceſſary to add another word on this ſubject; it remains that I riſk a conjecture or two, on the primary cauſe of the ſulphureous impregnation obſervable in theſe waters.

In the Chemical Eſſay before referred to, I have ſhewn, that the air ſeparable from the lead ore of Derbyſhire, or from Black-Jack, by ſolution in the acid of vitriol, impregnates common water with the ſulphureous ſmell of Harrogate water; and I have alſo ſhewn that the bladder fucus or ſea-wrack, by being calcined to a certain point, and put into water, not only gives the water a brackiſh taſte, but communicates to it, without injuring its tranſparency, the ſmell, taſte, and other properties of Harrogate water. Profeſſor *Bergman* impregnated water with a ſulphureous taſte and ſmell, by means of air ſeparated by the vitriolic acid from hepar ſulphuris, made by fuſion of equal weights of ſulphur and pot-aſhes, and from a maſs made of three parts of iron filings melted with two of ſulphur; and he found alſo, that Black-Jack and native Siberian iron yielded hepatic air, by ſolution in acids. This, I believe, is the main of what is known by chemiſts on this ſubject; what I have to ſuggeſt, relative to the Harrogate waters in particular, may perhaps be of uſe to future inquirers.

I have been told, that on breaking into an old coal-work, in which a conſiderable quantity of wood had been left rotting for a long time, there iſſued out a great quantity of water ſmelling like Harrogate water, and leaving, as that water does, a white ſcum on the earth over which it paſſed. On opening a well of common water, in which there was found a log of rotten wood, an obſervant phyſician aſſured me, that he had perceived a ſtrong and diſtinct ſmell of Harrogate water. Dr. *Darwin*, in his ingenious Account of an artificial Spring of Water, publiſhed in the firſt part of the LXXVth volume of the Philoſophical Tranſactions, mentions his having perceived a ſlight ſulphureous ſmell and taſte in the water of a well which had been ſunk in a black, looſe, moiſt earth, which appeared to have been very lately a moraſs, but which is now covered with houſes built upon piles. In the bog or moraſs above-mentioned there is great plenty of ſulphureous water, which ſeems to ſpring from the earth of the rotten wood of which that bog conſiſts. Theſe facts are not ſufficient to make us certain, that rotten wood is efficacious in impregnating water with a ſulphureous ſmell; becauſe there are many bogs in every part of the world, in which no ſulphureous water has ever been diſcovered. Nor, on the other hand, are they to be rejected as of no uſe in the inquiry; becauſe wood, at a particular period of its putrefaction, or when ſituated at a particular depth, or when incumbent on a ſoil of a particular kind, may give an impregnation to water, which the ſame wood, under different circumſtances, would not give.

The bilge water, uſually found at the bottom of ſhips which are foul, is ſaid to ſmell like Harrogate water: I at firſt ſuppoſed, that it had acquired this ſmell in conſequence of becoming putrid in contact with the timber on which it reſted, and this circumſtance I conſidered as a notable ſupport to the conjecture I had formed of rotten wood being, under certain circumſtances, inſtrumental in generating the ſmell of Harrogate water. But this notion is not well founded; for the bilge water is, I ſuppoſe, ſalt water; and Dr. *Short* ſays, that ſea water, which had been kept in a ſtone bottle ſix weeks "ſtunk not much ſhort of Harrogate ſulphur water." It has been remarked above, that calcined ſea-wrack, which contains a great deal of ſea ſalt, exhales an odour ſimilar in all reſpects to that of Harrogate water; and in confirmation of the truth of this remark, I find that an author, quoted by Dr. *Short*, ſays, that "Bay ſalt thrice calcined, diſſolved in water, gives exactly the odour of the ſulphur Well at Harrogate." From theſe experiments conſidered together, it may, perhaps, be inferred, that common ſalt communicates a ſulphureous ſmell to water both by putrefaction and calcination. Hence ſome may think, that there is ſome probability in the ſuppoſition, that either a calcined ſtratum of common ſalt, or a putreſcent ſalt ſpring, may contribute to the production of the ſulphureous ſmell of Harrogate water; eſpecially as theſe waters are largely impregnated with common ſalt. However, as neither the ſalt in ſea water, nor that of calcined ſea-wrack, nor calcined bay ſalt, are any of them abſolutely free from the admixture of bodies containing the vitriolic acid, a doubt ſtill remains, whether the ſulphureous exhalation, here ſpoken of, can be generated from ſubſtances in which the vitriolic acid does not exiſt.

The ſhale from which alum is made, when it is firſt dug out of the earth, gives no impregnation to water; but by expoſure to air and moiſture its principles are looſened, it ſhivers into pieces, and finally moulders into a kind of clay, which has an aluminous taſte. Alum is an earthy ſalt reſulting from an union of the acid of ſulphur with pure clay; and hence we are ſure, that ſhale, when decompoſed by the air, contains the acid of ſulphur; and from its oily black appearance, and eſpecially from its being inflammable, we are equally certain that it contains phlogiſton, the other conſtituent part of ſulphur. And indeed pyritous ſubſtances, or combinations of ſulphur and iron, enter into the compoſition of many, probably of all ſorts of ſhale, though the particles of the pyrites may not be large enough to be ſeen in ſome of them; and if this be admitted, then we need be at no loſs to account for the bits of ſulphur, which are ſublimed to the top of the heaps of ſhale, when they calcine large quantities of it for the purpoſe of making alum: nor need we have any difficulty in admitting, that a phlogiſtic vapour muſt be diſcharged from ſhale, when it is decompoſed by the air. Dr. *Short* ſays, that he burned a piece of aluminous ſhale for half an hour in an open fire; he then powdered and infuſed it in common water, and the water ſent forth a moſt intolerable ſulphureous ſmell, the very ſame with Harrogate water. He burned ſeveral other pieces of ſhale, but none of them ſtunk ſo ſtrong as the firſt. This difference may be attributed, either to the different qualities of the different pieces of ſhale which he tried, or to the calcination of the firſt being puſhed to a certain definite degree; for the combination of the principles on which the ſmell depends may be produced by one degree of heat, and deſtroyed by another. I have mentioned, briefly, theſe properties of ſhale, becauſe there is a ſtratum of ſhale extended over all the country in the neighbourhood of Harrogate; ſeveral beds of it may be ſeen in the ſtone quarry above the ſulphur wells; many of the brooks about Harrogate run upon ſhale, and the ſulphur wells ſpring out of it. They have bored to the depth of twenty yards into this ſhale, in different places, in ſearch of coal, but have never penetrated through it. Its hardneſs is not the ſame at all depths. Some of it will ſtrike fire, as a pyrites does, with ſteel; and other beds of it are ſoft, as if in a ſtate of decompoſition, and the ſulphur water is thought to riſe out of that ſhale which is in the ſofteſt ſtate. But whatever impregnation ſhale when calcined, or otherwiſe decompoſed to a particular degree, may give to the water which paſſes over it, it muſt not be concluded, that ſhale in general gives water a ſulphureous impregnation; ſince there are many ſprings, in various parts of England, ariſing out of ſhale, in which no ſuch impregnation is obſerved.

I forgot to mention, in its proper place, that having viſited the bog, ſo often ſpoken of, after a long ſeries of very dry weather, I found its ſurface, where there was no graſs, quite candied over with a yellowiſh cruſt, of tolerable conſiſtency, which had a ſtrong aluminous taſte, and the ſmell of honey. *Bergman* ſpeaks of a turf found at Helſingberg in Scania, conſiſting of the roots of vegetables, which was often covered with a pyritous cuticle, which, when elixated, yielded alum; and I make no doubt, that the Harrogate moraſs is of the ſame kind.

Whether nature uſes any of the methods which I have mentioned of producing the air by which ſulphureous waters are impregnated, may be much queſtioned; it is of uſe, however, to record the experiments by which her productions may be imitated; for though the line of human underſtanding will never fathom the depths of divine wiſdom, diſplayed in the formation of this little globe which we inhabit; yet the impulſe of attempting an inveſtigation of the works of God is irreſiſtible; and every phyſical truth which we diſcover, every little approach which we make towards a comprehenſion of the mode of his operation, gives to a mind of any piety the moſt pure and ſublime ſatisfaction.

ESSAY II.

Experiments and Obſervations on various Phænomena attending the Solution of Salts.

HAVING lately had occaſion, in ſome chemical inquiries, to make various ſolutions of ſalts, I met with ſome phænomena, which did not appear to me either to have been ſufficiently attended to, or conſiſtently explained by writers upon that ſubject. The ſuſpenſion of ſalts in water, of metals in acids, of ſulphur in oils, and of other bodies in menſtruums ſpecifically lighter than the bodies themſelves, hath ever been conſidered in chemiſtry, as a problem of difficult ſolution. Thoſe philoſophers who acquieſce, upon the whole, in the cauſe which hath been aſſigned for this phænomenon by Sir Iſaac Newton, in his optical Queſtions, have taken great pains to illuſtrate the manner how it is effected, by ſuppoſing that the bodies are received into the pores of their reſpective menſtruums, and there kept ſuſpended by the attraction or, as Bernouilli and Freind would have it, by the reſiſtance ariſing from the tenacity of the fluid. Hence it happens, ſay theſe philoſophers, that after water is ſaturated with one ſalt, it is ſtill capable of diſſolving ſomewhat of a ſecond kind, and being ſaturated with that, of a third, and ſo on; juſt as a veſſel filled as full as poſſible with ſpheres or cylinders of one magnitude hath a capability of receiving ſimilar bodies of an inferior ſize, or bodies of a different figure. The opinion of Gaſſendus ſeems to have been generally adopted; he endeavours to prove, from the experiment which hath been mentioned, not only the poroſity of water, but a diverſity in the figures of the pores: *Affero & aliud experimentum ſingulare, quo viſus ſum mihi deprehendere interſperſa hujuſmodi ſpatiola inania intra aquam dari.—Aiebam, cum ſint ſalis corpuſcula cubica, poterunt ea quidem replere ſpatiola, quæ & ipſa cubica fuerint; at cum non modo commune ſal, ſed alumen etiam, quod eſt octahedricum, halinitrum item, & ſal ammoniacum ſaccharumque & alia quæ aliarum ſunt figurarum eâdem aquâ exſolvi poſſunt; erunt ergo etiam in aqua*

aqua ſpatiola octahedrica atque id genus alia; adeo ut aqua, tametſi ſale ſaturata fuerit, nihilominus & alumen et cetera omnia exſolvere poſſit ac in ſeſe transfundere. Gaſ. Phyſ. l. i. ſect. 1. cap. iii. The reaſon why warm water diſſolves in general more ſalt than cold water, ſeems as if it might be derived from the ſame principle, was it true; the interſtices between the elementary particles of water are enlarged by the expanſion of the fluid, and might therefore be ſuppoſed capable of admitting into them a larger quantity of ſalt. This doctrine hath been embraced by moſt philoſophers, eſpecially by the late Abbé Nollet, in the 4th volume of his Leçons de Phyſique; and I do not know that it hath been oppoſed by any body. The late Mr. Eller, of Berlin, hath carried this ſpeculation ſo far, as to publiſh a Table in the Berlin Memoirs for 1750, exhibiting the ſeveral quantities of above twenty different kinds of ſalt, which a given quantity of water will abſorb into its pores, without being in the leaſt augmented in bulk. It is not therefore without ſome uneaſineſs that I find myſelf conſtrained to diſſent from the general opinion, and particularly to differ from Mr. Eller, who hath treated this ſubject *ex profeſſo*; who made his experiments, as he himſelf aſſures us, with the greateſt exactneſs; and who was led by them to the diſcovery of what he is pleaſed to call, *une verité inconteſtable, ſavoir, que les plus petites parties conſtituantes de l'eau ſont doüees de pores ou d'interſtices dans leſquels les atomes de ſel peuvent nicher, ſans augmenter* *leur volume.* I do not at preſent ſee any very probable method of reconciling the different reſults of our inquiries; I will therefore content myſelf with giving a plain relation of the experiments which I have made upon this ſubject.

EXPERIMENT I.

I took a large mattraſs, containing, when filled to the middle of its neck, 132 ounces of water, Troy weight; the diameter of the cavity of the neck was ſix lines: having with a diamond marked the place where the water ſtood in the neck of the mattraſs, I dropped into it a ſingle piece of purified nitre, the weight of which was a 2600th part of the weight of the water, and immediately obſerved that the water was conſiderably elevated in the tube:

during the ſolution of ſalt, the water ſunk near one third of its whole elevation; but when the ſolution was entirely finiſhed, it remained very ſenſibly raiſed above the mark: ſo that, even from the experiment with this inſtrument, we may be aſſured that water cannot abſorb $\frac{1}{2000}$th part of its weight of nitre, without being augmented in bulk. Mr. Eller, from his experiments, concludes, that eight ounces of water will abſorb one drachm and a half, or above a 42d part of its weight of nitre; and hence I ſuppoſed the quantity of water which I uſed would have abſorbed above ſixteen times as much, or above three ounces; whereas the event ſhewed that it could not abſorb $\frac{1}{20}$ of an ounce. From the ſinking of the water during the ſolution, I was at firſt inclined to believe that ſome part at leaſt of the nitre was taken into the pores of the water: in order to ſee whether this conjecture could be verified by fact, I made the following experiment.

EXPERIMENT II.

I choſe two matraſſes of unequal ſizes, containing quantities of water in the proportion of 12 to 1, the diameters of the necks being equal: into the largeſt I put $\frac{1}{650}$th part of the water's weight of nitre, and an equal quantity into the ſmaller; and I obſerved that the water, as well before as after the ſolution, was equally elevated in them both: this experiment was repeated. Now, if a given quantity of water can abſorb into its pores, without being increaſed in magnitude, any quantity of ſalt however ſmall, it ſeems reaſonable to ſuppoſe that a quantity containing twelve times as many pores ſhould abſorb twelve times as much, (ſince it is an allowed fact that the minuteſt portion of a ſalt is uniformly diffuſed through the largeſt quantity of water) and it might conſequently be expected, that the water ſhould riſe higher in the neck of the ſmaller matraſs than in that of the larger, which is contrary to the experiment.

EXPERIMENT III.

Apprehending that common pump water, with which I had made the preceding experiments, might have its interſtices preoccupied by ſelenites and other heterogeneous matters, and be thereby rendered incapable of admitting into them any additional ſubſtance; and obſerving that Mr. Eller had uſed in all his experiments

riments 8 ounces of diſtilled water, I had hopes to have reconciled my experiments to his by that means: but upon trial, with diſtilled water, I found the elevation preciſely the ſame as before. Nor do the concluſions depend upon the kind of ſalt; they hold true *mutatis mutandis* of any other ſalt as well as nitre. During the ſolution the water is refrigerated and thereby contracted in magnitude, and the ſmaller the quantity the greater will be the cold and conſequent contraction produced by the addition of ſmall portions of ſalt; but I cannot ſuppoſe that this circumſtance could be overlooked by Mr. Eller, though it induced me to uſe a much larger quantity, or that he attributed the ſinking of the water during the ſolution, to an imbibition of the particles of the ſeveral ſalts into the pores of the water, and thence by calculation conſtructed his table.

EXPERIMENT IV.

Having always remarked that the water in the neck of the matraſs was elevated higher upon the firſt immerſion of the ſalt, than after it was wholly diſſolved, I endeavoured to aſcertain the difference in ſeveral kinds of ſalt. To do this with the greater exactneſs, I pitched upon a matraſs which had a neck as far as I wanted it accurately cylindrical, as I found by obſerving the elevations occaſioned by the additions of equal portions of water; the matraſs held about 67 ounces of water. The ſalts I uſed were all dry, and in as large pieces as the neck of the matraſs would admit; the water was heated to the forty-ſecond degree of Fahrenheit's thermometer, and kept as nearly as could be in that temperature. I changed the water for each experiment, and uſed in each 24 penny weights of ſalt; the heights to which the water roſe, as meaſured from a mark in the middle of the tube, before and after the ſolution of each ſalt, are expreſſed in the following table: the firſt column denotes the height to which the water was elevated by 24 penny weights of ſalt before its ſolution, the ſecond after its ſolution, the third the difference in fractional parts of the elevation before ſolution.

Elevation by 24 penny weights of ſimple water	0	58	
24 penny weights of genuine Glauber's ſalt	42	36	$\frac{1}{7}$
Vol. ſalt of ſal. ammon.	40	33	$\frac{7}{40}$

Sal

Sal ammon.	40	39	$\frac{1}{40}$
Refined white ſugar	39	36	$\frac{1}{13}$
Coarſe brown ſugar	39	36	$\frac{1}{13}$
White ſugar candy	37	36	$\frac{1}{37}$
Glauber's ſalt from Lymington	35	29	$\frac{6}{35}$
Terra foliata tar.	37	30	$\frac{7}{37}$
Rochelle ſalt	33	28	$\frac{5}{33}$
Alum not quite diſſolved	33	28	$\frac{5}{33}$
Borax not half diſſolved in 2 days	33	31	$\frac{2}{33}$
Green vitriol	32	26	$\frac{3}{16}$
White vitriol	30	24	$\frac{1}{5}$
Nitre	30	21	$\frac{3}{10}$
Sal gem. from Norwich	27	17	$\frac{10}{27}$
Blue vitriol	26	20	$\frac{3}{13}$
Pearl aſh	25	10	$\frac{3}{5}$
Vitriolated tartar	22	11	$\frac{1}{2}$
Green vitriol calcined to whiteneſs	22	11	$\frac{1}{2}$
Dry ſalt of tartar	21	13	$\frac{8}{21}$
Baſket ſea ſalt	19	15	$\frac{4}{19}$

Corroſive ſublimate	14	10	$\frac{2}{3}$
Turbith mineral	9	0	

Had I not been in ſome meaſure perſuaded, from the reſult of the preceding experiments, that no portion of any ſalt could be abſorbed into the pores of water, I ſhould have readily concluded that the third column of this table denoted ſuch parts of 24 penny weights of the ſeveral ſalts as might be lodged in the interſtices of 67 ounces of water, without increaſing its magnitude: the quantities indeed which might have been thus aſcertained would have but ill agreed with thoſe which are determined by Mr. Eller; and that diverſity of quantity may ſuggeſt a doubt concerning the validity of his principle. The ſinking of the water in the neck of the matraſs ſeems to be a general phænomenon attending the ſolution of all ſalts; the quantity of the deſcent is various from $\frac{1}{40}$ to $\frac{1}{2}$ of the whole elevation in thoſe ſalts which I have tried. In forming the table, I repeated many of the experiments, but found no variation which could affect the general concluſion; with particular attention I repeated the ſolution of vitriolated tartar, for I thought it a very remarkable circumſtance that one of the hardeſt ſalts ſhould be more diminiſhed in proportion to its whole bulk than any other, but the numbers in the table 22 and 11 accurately expreſſed the height before and after ſolution upon the repetition of the experiment, ſo that it may be relied upon as a certain fact that a cubic inch of vitriolated tartar is by ſolution in water reduced to half a cubic inch, though the water cannot, as appeared from an experiment I made, abſorb $\frac{1}{1000}$th part, nor, as I believe, any part, of that ſalt without being augmented in magnitude. It is evident from the table that ſal gemmæ, blue vitriol, corroſive ſublimate, calcined vitriol, and in general thoſe ſalts which retain the leaſt water in their compoſition and conſtitute the hardeſt maſſes, ſink more in proportion to their reſpective bulks than any other. I own myſelf at a loſs for a general principle to explain this general phænomenon, unleſs the air contained in the ſeveral ſalts may be eſteemed ſufficient for the purpoſe; a very copious ſeparation of air from the ſalts during the whole time of their ſolution may be readily obſerved in all of them, and a ſmall portion of it, combined with the particles of a ſalt, may augment its bulk, without ſenſibly increaſing its weight. Yet the two following experiments rather tend to diminiſh the probability of this opinion.

EXPERIMENT V.

I took water which had been well purged from its air by long boiling, and which had been corked up whilſt it was warm; when it had acquired a proper temperature, I filled a matraſs with it, as before, and putting into it ſal gemmæ, &c. I obſerved that the elevation before ſolution was the ſame as when common water was uſed, and that it ſunk equally in the neck during the ſolution; but then the ſeparation of air ſeemed greatly leſs in all the trials I made. This phænomenon is eaſily explained:

common water is always ſaturated with air; upon the addition of any ſalt, the particles of water begin to attract and diſſolve the ſalt, and let go the air with which they are united; this air, added to the air contained in the ſalt, renders the whole much more viſible in common than in boiled water. Muſſchenbrook and others are of opinion, that air only fills the interſtices of water, without augmenting its bulk; they ground their opinion upon obſerving that the ſpecific gravities of common water and of water purged from its air are equal; the fact, taking it for granted, will ſcarcely authorize the concluſion: for, ſuppoſing that a cubic inch of common water contains even a cubic inch of air, the difference of the weight of the water when ſaturated with air, and when freed as much as poſſible from it (though probably it can never be wholly freed from it), will not equal $\frac{1}{4}$ of a grain: how imperceptible then muſt the difference be, if water, inſtead of an equal bulk, doth not contain $\frac{1}{100}$th part of its bulk of air, which is a ſuppoſition much nearer to the truth: the air is ſeparated from the water during the ſolution of the ſalt, and the particles of the ſalt probably occupy its place as happens in other chemical precipitations; but we cannot thence infer that they are received into the interſtices of the water, unleſs we had more concluſive arguments, to prove that the air itſelf was lodged in them. I varied the preceding experiment by putting two equal and tranſparent pieces of ſal gemmæ into two tall drinking glaſſes, filled one with common, the other with boiled water; from the firſt there continually aſcended a very viſible ſtream of air, and the ſalt and the bottom of the glaſs were covered with bubbles, it ſeeming as if the water quitted its air to diſſolve the ſalt; in the other, though ſome air was ſeen breaking out from the ſalt whilſt it was diſſolving, there did not ſeem to be any precipitated, as it were, from the water. In moſt of the experiments which I made, the boiled water diſſolved a given quantity of ſalt ſooner than the common water, when they had the ſame degree of heat; but the difference in time might be owing to the different magnitude of the ſurfaces of the ſalt, though from the generality of the event, I ſhould rather attribute it to the different diſſolving powers of water, when replete with, and when deprived of air.

EXPERIMENT VI.

Thinking that the difference in the bulks of the water before and after ſolution might be owing to the ſeparation and eſcape of ſome volatile principle; I took care to balance as accurately as I could, water and ſal gemmæ, water and ſalt of tartar, water and vitriolated tartar, &c. and then putting the ſeveral ſalts into the water, I obſerved when the ſolution was accompliſhed, whether the equilibrium of the ſcales was affected, but I could not diſtinguiſh any change. Dr. Hales and others have ſpoken of the exiſtence of air in ſalts, and have in two or three inſtances inveſtigated the quantity, but after a very different manner from that I have uſed; nor can I think myſelf at liberty to eſteem this air which is ſeparated by ſolution, of the ſame nature with that which is called by him and others fixed air, inaſmuch as fixed air makes a conſiderable part of the weight of the bodies from which it is extracted, precipitates lime water, and is ſeldom diſcharged (or perhaps produced from ſome of the minute parts of the body being converted by the violence of the fire, &c. into an elaſtic fluid), except when the body is decompoſed; whereas this makes only a conſiderable part of the bulk of bodies, and thus diminiſhes their ſpecific gravity without ſenſibly increaſing their abſolute weight; does not, as I collected from ſome rough trials, render lime water turbid; and is ſet at liberty, though not by a mechanical diviſion, yet by an operation ſomewhat different from chemical decompoſition. It hath been remarked by ſome, that ſaline ſolutions will not cryſtallize without much difficulty in an exhauſted receiver; perhaps becauſe the particles of ſalt cannot attract that principle which ſhould cement them together, which at leaſt may be ſeen eſcaping from them when they begin to be ſeparated. Mr. Boyle obſerved, that aquafortis, poured upon a ſtrong vegetable alcali, did not cryſtallize till it had been long expoſed to the air (though I ſhould rather attribute this failure to the weakneſs of his aquafortis than to the want of air, ſince I have frequently, by uſing the fuming ſpirit of nitre, obtained cryſtals of an inch in length almoſt inſtantaneouſly);

and ſeveral other phænomena might be adduced reſpecting the cryſtallization of ſalts, which ſeem to indicate the neceſſity of admitting air as a very efficacious inſtrument in producing that effect: but future experience may tend to elucidate this matter. Having uſed great attention in making the experiments from which the preceding table was compoſed; I thought I had a good opportunity of deriving from it the ſpecific gravities of the ſalts which are there mentioned. I accordingly calculated the following table; in the firſt column of which are expreſſed the ſpecific gravities as calculated from the increaſe of bulk before ſolution; in the ſecond, after the ſolution.

Genuine Glauber's ſalt	1,380	1,611
Cryſtals of kelp	1,414	1,467

Volat. ſalt of ſal ammoniac	1,450	1,787
Sal ammoniac	1,450	1,487
Sugar refined, brown, barley	1,487	1,611
White ſugar candy	1,567	1,611
Terra foliata tartari	1,567	1,933
Glauber's ſalt from Lymington	1,657	2,000
Rochelle ſalt	1,757	2,071
Alum	1,757	2,071
Borax	1,757	
Green vitriol	1,812	2,230
White vitriol	1,933	2,416
Nitre	1,933	2,766
Very tranſparent ſal gem. from Northwich	2,143	3,411
Blue vitriol purified	2,230	2,900
Pearl aſh	2,320	5,800
Vitriolated tartar	2,636	5,272
Green vitriol calcined to whiteneſs	2,636	5,272

Dry ſalt of tartar	2,761	4,461
Baſket ſea ſalt	3,052	3,866
Corroſive ſublimate	4,142	5,800
Mercury diſtilled with acid of vitriol, and freed from its acid by a ſtrong fire	6,444	

The numbers in the firſt column correſpond very well, upon the whole, with the ſpecific gravities which have been determined by others hydroſtatically; thus the ſpecific gravities of nitre, alum, white and green vitriol, ſal ammoniac, ſal gemmæ, &c. are greater than what are aſſigned to theſe bodies by ſome authors, and leſs than what have been determined by others; it ſeems as if the ſpecific gravities of ſaline bodies might, in a proper veſſel, be more accurately aſcertained from the obſerved increaſe of the water's bulk than any other way. Upon the ſuppoſition that the eſcape of the air is the reaſon of the water's ſinking during the ſolution, and that this air contributes little to the weight of the ſalts, though it may be abſolutely neceſſary to the exhibiting the ſaline moleculæ under a viſible cryſtalline appearance; the ſecond column will denote the real ſpecific gravities of the ſalts as freed from air. That this air is combined with the ſalts, and doth not ſimply adhere to their ſurfaces, may appear from hence, that the ſpecific gravities, as calculated from the increaſe of bulk obſerved in the water before ſolution, ſufficiently correſpond with thoſe which philoſophers have determined hydroſtatically: nor indeed, upon exhauſting the air from the ſalts, by an air pump, could I obſerve that it was ſeparated, in leſs quantity during ſolution.

EXPERIMENT VII.

Since equal quantities of ſalt muſt contain equal quantities of air, it might be expected *a priori*, if the eſcape of the air was the occaſion of the water's ſinking, that equal weights of ſalt would produce equal augmentations of bulk, and unequal weights augmentations proportionable to their weights; but, to be aſſured of this, I took a matraſs containing about 30 ounces of water, the tube being cylindrical for about 7 inches in length. When the matraſs was filled to a proper mark, I put into it 7 pennyweights of powdered ſal gem.: the water after the ſolution had riſen through 17 tenths of an inch; by the addition of 14 pennyweights more, the water was raiſed through 51 diviſions from the firſt mark, or twice 17 from where it ſtood after the ſolution of 7 pennyweights. In the ſame matraſs I tried a ſimilar experiment with nitre; the water was raiſed through 10 diviſions, by 3 pennyweights of powdered nitre; and by 18 more, it ſtood after the ſolution at the 70th diviſion from the firſt mark, and conſequently roſe through ſix times the ſpace, through which it had been raiſed by 3 pennyweights. From theſe, and other experiments of the ſame kind, I am diſpoſed to believe that equal portions of ſalt produce equal augmentations in the bulk of the water wherein they are diſſolved; at leaſt, this holds true when the ſalt diſſolved bears but a ſmall proportion to what would be requiſite to ſaturate the water. But, in making this experiment, great care muſt be taken to keep the ſalts of the ſame dryneſs; I had once tried it with three equal quantities of ſea ſalt, and arrived at a quite different concluſion; the increaſes of bulk occaſioned by the ſolution of the ſeveral ſalts being ſeparately taken, as 15, 16, 17, but the ſalt being much drier than the air in the laboratory, had undoubtedly attracted the humidity, and that portion had attracted the moſt which had been the longeſt in it, and which was laſt diſſolved. Nor ſhould the temperature of the water be neglected; a ſenſible error may proceed from a minute change in that. This experiment confirms the firſt, for, was any part of ſalt abſorbed into the pores of the water, it certainly ought to be expected that the elevation occaſioned by the ſolution of 3 pennyweights of nitre ſhould be leſs than $\frac{1}{6}$th of that occaſioned by 18 pennyweights, and yet I found it to be accurately $\frac{1}{6}$th upon repeating the experiment with diſtilled water. It confirms it too in another view, 3 pennyweights or $\frac{1}{200}$th part of the weight of the water, raiſed it through one inch; hence $\frac{1}{2000}$th part would have raiſed it through one tenth of an inch, which any eye may diſtinguiſh.

Dr. Lewis, for whoſe great abilities in chemiſtry I have a very high reſpect, in his little treatiſe upon American potaſhes, is of opinion, that the augmentation of the bulk of water doth not proceed uniformly, according to the quantity of ſalt added; and he forms his concluſion from obſerving, that the loſſes of weight ſuſtained by the ſame body in different ſolutions, were not uniform, but continually diminiſhed; the loſſes correſponding to ſeven ſucceſſive equal quantities being as 24½. 24. 23½. 22. 22. 21. 20. Upon conſidering this matter in a mathematical light, I am inclined to draw a quite different concluſion; but I will firſt mention ſome experiments which I had formerly made with a different view, and which agree very well with Dr. Lewis's.

EXPERIMENT VIII.

I had conceived that if, in a given quantity of water, ſeveral quantities of ſalt, increaſing in any arithmetical or geometrical progreſſion, were diſſolved; that the increments of ſpecific gravity would increaſe in the ſame progreſſion. In order to ſee whether this conjecture could be eſtabliſhed by experiment, I diſſolved in a given quantity of water, different portions of ſea ſalt, increaſing in the progreſſions expreſſed in the annexed tables, where the firſt column of each denotes the proportional quantities of ſalt in pennyweights; the ſecond, the loſs of weight of a given body in quarter grains; the third, the exceſs of the ſpecific gravity of each ſolution, above the ſpecific gravity of water.

TAB. I.

	263	0
9	273	10
18	282	19
27	292	29
36	301	38
45	309	46

TAB. II.

	263	0
5	269	6
10	274	11
15	280	17
20	285	22
25	289	26
30	294	31
35	300	37
40	304	41
45	309	46
50	312	49
55	316	53

TAB. III.

	883	0
4	899	16
8	915	32
12	930	47
16	945	62
20	959	76
24	971	88
28	985	102
32	996	113
36	1009	126
40	1020	137

The difference of the numbers in the third column of each table from arithmetical progreſſions, is obvious at firſt view, the difference of the two laſt numbers of each being conſiderably leſs than the difference between the two firſt: and the numbers 6. 11. 22. 41. correſponding to the geometrical progreſſion 5. 10. 20. 40. in the ſecond table as well as the numbers 16. 32. 62. 113 correſponding to the geometrical progreſſion 4. 8. 16. 32, in the third, differ conſiderably from geometrical progreſſions, whoſe common ratio is $\frac{1}{2}$.

In making theſe experiments there are three obvious ſources of error: the heat may not remain conſtant; the additional weights of ſalt may not be accurately equal; and the weight of the given body may be more or leſs than what is expreſſed by any quantity leſs than $\frac{1}{4}$ of a grain; yet the differences of the preceding numbers, from arithmetical or geometrical progreſſions, are too great to be explained from any or all of theſe ſources taken together. We may obſerve that the loſſes of weight, correſponding to equal portions of ſalt, are, upon the whole, diminiſhed; but it will not follow from thence that the bulks are not equally augmented. For, ſince the ſpecific gravity of every body is properly denoted by a fraction, whoſe numerator expreſſes the abſolute weight, and denominator the magnitude of the body; let $\frac{w}{m}$, $\frac{w+x}{m+y}$, $\frac{w+2x}{m+z}$, $\frac{w+3x}{m+s}$, &c. be a ſeries of fractions, whoſe ſeveral numerators expreſs the weights of a given quantity of water, as increaſed by the addition of equal portions of any ſalt denoted by x, and whoſe denominators expreſs the bulks of the water after the ſolution of each portion of ſalt, the increments of bulk being denoted by y, z, s; now let us ſuppoſe that the loſſes of weight ſuſtained by the ſame body, that is, the ſpecific gravities, increaſe uniformly, then will the above ſeries of fractions increaſe uniformly, let $\frac{w}{m}=a$; $\frac{w+x}{m+y}=a+b$; $\frac{w+2x}{m+z}=a+2b$; $\frac{w+3x}{m+s}=a+3b$, from theſe equations inveſtigating the proportion between y, z, s, which repreſent the augmentations of bulk, it will appear that $y : z :: a+2b : 2a+2b$, or in a greater ratio than that of 1 : 2 and that $z : s :: 2a+6b : 3a+6b$, or in a greater ratio than that of 2 : 3, in which ratios they ought reſpectively to have been, had the denominators or the bulks of the fluid increaſed uniformly, when the ſpecific gravities or abſolute weights increaſed uniformly. We ſee from this, what concluſion ſhould have been formed, had the increments of ſpecific gravity from equal portions of ſalt been equal. Again, ſuppoſe that $\frac{w}{m}, \frac{w+p}{m+q}, \frac{w+2p}{m+2q}, \frac{w+3p}{m+3q}$, &c. denote a ſeries of fractions, whoſe numerators, expreſſing the weights of a given quantity of water as increaſed by the addition of ſalt, and whoſe denominators, expreſſing the bulks, both increaſe uniformly, then will the ſeveral differences between the 2d and 1ſt, between the 3d and 2d, and ſo on, be as $\frac{1}{m \times \overline{m+q}}, \frac{1}{\overline{m+q} \times \overline{m+2q}}, \frac{1}{\overline{m+2q} \times \overline{m+3q}}, \frac{1}{\overline{m+3q} \times \overline{m+4q}}$, &c. which fractions being inverſely as their denominators conſtitute a decreaſing ſeries; but the increments of ſpecific gravity from the addition of equal portions of ſalt, are proportionable to theſe fractions, and therefore ought perpetually to decreaſe, though we allowed the bulk of the compound to be preciſely equal to the bulk of the water and ſalt taken together, that is, though we allowed the bulk of the water to increaſe uniformly according to the quantity of ſalt added: now as it is evident from Dr. Lewis's experiments, and from each of the preceding tables, that the increments of ſpecific gravity do decreaſe upon the whole, when the abſolute weights increaſe uniformly, we may venture to conclude that the bulks increaſe uniformly alſo. I thought proper to explain the foregoing principle and to determine the ratio, becauſe the matter ſeems to have been miſtaken by many; however, it may be eaſily apprehended that the increments of ſpecific gravity, from the addition of equal quantities of ſalt to a given weight of water, ought perpetually to decreaſe; becauſe the difference between the ſpecific gravities of the water and of the ſalt perpetually decreaſes, as the water approaches to perfect ſaturation. In like manner, if to a given quantity of water we add any number of equal quantities of oil of vitriol, or any fluid miſcible with and heavier than water; the increments of ſpecific gravity will perpetually decreaſe, though they will never entirely vaniſh, becauſe there is a perpetual approximation to the ſpecific gravity of the acid, which yet the mixture can never acquire; and, *vice verſa*, if to water we add a lighter fluid, as ſpirits of wine by equal portions, the ſpecific gravity of the mixture will conſtantly decreaſe by unequal decrements; but the decrements will never vaniſh, becauſe the mixture muſt ever remain ſpecifically heavier than ſpirit of wine.

EXPERIMENT IX.

The quantities of various ſalts, which may be diſſolved in a given quantity of water, have been aſcertained by Boerhaave, Eller, Spielman, and others; their accounts differ ſomewhat from one another, as might be expected from the different temperatures of the air, the different ſtate of their ſalts, the different times (a circumſtance of no ſmall conſideration in this matter) which they allowed the water to act upon the ſalts before they concluded it to be fully ſaturated, and from ſome other circumſtances which might perhaps with advantage be taken into the account, and a more accurate table compoſed than hath hitherto been publiſhed; but as the differences would be ſmall, and might not tend to any new diſcoveries, I could not perſuade myſelf to be at the trouble of making the requiſite experiments. I thought it would be a more uſeful undertaking to determine the ſpecific gravities of ſaturated ſolutions of various ſalts. In compoſing the following table, I uſed every poſſible precaution; the ſolutions were fully ſaturated, by permitting the water to reſt upon the ſalts for ſome weeks, and frequently ſhaking the ſolutions during the interval: I had ſome reaſons for chooſing this method rather than the much ſhorter one of diſſolving the ſalts in hot water, and letting the ſolutions cool, though the event will be much the ſame in both ways; my balance was extremely ſenſible, though I did not uſe any weight leſs than a quarter of a grain; the water in which the ſalts were diſſolved was not $\frac{1}{4}$ of a grain in 890 heavier than diſtilled water; the ſolutions were all of the ſame temperature, Fahrenheit's thermometer ſtanding between 41 and 42° during the whole time of taking the ſpecific gravities.

A Table exhibiting the ſpecific gravities of water ſaturated with various ſalts. Thermometer 41 —42°, barometer 30 inches.

Water in which the ſalts were diſſolved	1,000
Saturated with quicklime	1,001
Cryſtals of tar	1,001
Arſenic	1,005
Borax	1,010
Corroſ. ſublim.	1,037
Alum	1,033
Genuine Glauber's ſalt	1,052
Vitriolated tart.	1,054
Common ſalt	1,198
Arſen. nitre	1,184
Glau. ſalt Lyming.	1,232
Sal ammon.	1,072
Vol. ſalt of ſal am.	1,077
Cryſtals of kelp	1,087
Nitre purified	1,095
Rochelle ſalt	1,114
Blue vitriol	1,150

Green vitriol	1,157
Sal gemmæ	1,170
Epſom ſalt Lym.	1,218
White vitriol	1,386
Pearl aſh	1,534

By making other tables ſimilar to the preceding, when the thermometer ſtands at 62°, 82°, 102°, &c. or when the heat increaſes or decreaſes in any known ratio; it is extremely probable that the law, according to which the diſſolving power of water varies with the variation of its heat, might be inveſtigated. I have ſome reaſons for thinking that though it increaſes with the increaſe of heat, yet it doth not increaſe in the direct ſimple ratio of the heat; but what the law is, or whether all ſalts follow the ſame law, I cannot, from any experiments I have already

2 made,

made, determine; and I have no leiſure at preſent to proſecute the inquiry. The concluſion will be unavoidably liable to a ſmall inaccuracy; for whether the ſpecific gravities be inveſtigated by weighing the ſeveral fluids in a given veſſel filled to a given mark, or by weighing a given ſolid in each of them, we ſhall not thence obtain the weights of equal bulks, ſince the containing veſſel or the ſolid, from the difference of the heats, have a different capacity or a different bulk. However, it is not apprehended that this circumſtance would ſenſibly affect the concluſion, eſpecially as it is ſubject to calculation and might be allowed for. It ought, at the ſame time, to be obſerved, that a given bulk of the water with which the ſpecific gravities are compoſed,

will

will have different weights when the heats are different; and theſe differences ought firſt to be aſcertained.

EXPERIMENT X.

Having thus determined the ſpecific gravities of ſaturated ſolutions of ſeveral ſalts, in a given degree of heat; my next inquiry was to find the ſpecific gravities of water impregnated with a given quantity of the ſeveral ſalts: I accordingly diſſolved in 168 pennyweights of water, 14 pennyweights, or $\frac{1}{12}$ of the weight of the water of the eight following ſalts. The thermometer was at 40° and barometer at $29\frac{1}{2}$.

A Table of the ſpecific gravities of water impregnated with $\frac{1}{12}$ of its weight of

Water	1,000
Sea ſalt	1,059

Blue vitriol	1,052
Nitre	1,050
White vitriol	1,045
Green vitriol	1,043
Glau. ſalts Lym.	1,039
Glau. ſalts Genu.	1,029
Sal ammon.	1,026

I could not have made this table much more extenſive, ſince in the 40th degree of the thermom. water will not diſſolve $\frac{1}{12}$ of its weight of alum, borax, vitriolated tartar, corroſive ſublimate, and a great many other ſalts; however, as ſuch a table cannot fail of being uſeful in chemical, and perhaps medical reſearches, it would be worth while to make it more general, either by diſſolving a leſs portion of ſalt, or making uſe of a greater degree of heat.

EXPERIMENT XI.

To theſe tables I have ſubjoined another of a different nature, wherein the ſpecific gravities of water impregnated with different quantities of the ſame ſalt from $\frac{1}{3}$ down to the 1024th part of the weight of the water, are determined. I cannot accuſe myſelf of careleſſneſs in making any of the experiments from which the table is formed; but part of it being made in a room where the heat was about 55°, and the other in my laboratory, when it did not exceed 46°, a certain inaccuracy, though it will be a very ſmall one, and ſcarce ſenſible in the weight of the ſmall body which I uſed, will attend it upon that account. The ſalt was ſea ſalt of the fineſt kind, and extremely dry; many of the experiments were repeated.

A Table of the ſpecific gravity of water impregnated with different quantities of ſea ſalt. Thermometer between 46 and 55°.

Water	1,000
Salt $\frac{1}{3}$	1,206
$\frac{1}{4}$	1,160
$\frac{1}{5}$	1,121
$\frac{1}{6}$	1,107
$\frac{1}{7}$	1,096
$\frac{1}{8}$	1,087
$\frac{1}{9}$	1,074
$\frac{1}{12}$	1,059
$\frac{1}{14}$	1,050
$\frac{1}{15}$	1,048
$\frac{1}{16}$	1,045
$\frac{1}{18}$	1,040
$\frac{1}{21}$	1,032
$\frac{1}{24}$	1,029

$\frac{1}{27}$	1,027
$\frac{1}{28}$	1,025
$\frac{1}{30}$	1,024
$\frac{1}{32}$	1,023
$\frac{1}{36}$	1,020
$\frac{1}{39}$	1,019
$\frac{1}{42}$	1,015
$\frac{1}{48}$	1,014
$\frac{1}{54}$	1,013
$\frac{1}{55}$	1,012
$\frac{1}{72}$	1,009
$\frac{1}{84}$	1,007
$\frac{1}{108}$	1,006
$\frac{1}{126}$	1,005
$\frac{1}{144}$	1,004
$\frac{1}{162}$	1,003
$\frac{1}{192}$	1,0029
$\frac{1}{256}$	1,0023
$\frac{1}{320}$	1,0018
$\frac{1}{448}$	1,0017
$\frac{1}{512}$	1,0014

$\frac{1}{848}$	1,0008
$\frac{1}{1024}$	1,0006

From this table it will be eaſy to determine how much the ſpecific gravity of water is increaſed by the ſolution of a given quantity of ſalt, and, *vice verſa*, if we know the ſpecific gravity of any ſolution of ſalt, we may form a good conjecture of the quantity of ſalt contained in it, which obſervation may be of ready uſe in eſtimating the ſtrength of brine ſprings, and of ſea water, taken up in different climates, or upon different coaſts in the ſame climate. Thus, if a ſalt ſpring, or ſea water, ſhould weigh $\frac{1}{50}$ more, bulk for bulk, than common water; we may conclude that it contains $\frac{1}{36}$ of its weight of ſalt; if $\frac{1}{40}$, it hath nearly $\frac{1}{28}$; if $\frac{1}{25}$, $\frac{1}{18}$; if $\frac{1}{20}$, $\frac{1}{14}$; and ſo on: we may always find limits near enough to form a concluſion from, though the exact number denoting the weight in any particular caſe ſhould not be met with in the table.

After I had drawn up the preceding account of the experiments which I had made, I received the Berlin Memoirs for 1762, publiſhed laſt year, in which there is a memoire entitled---*Experiences ſur le poids du ſel et la gravité ſpécifique des ſaumures faites et analyſées, par M. Lambert*. In this memoire, the very ingenious author hath made much uſe of the principle, which I have endeavoured to call in queſtion in the beginning of this paper; and hath calculated the different quantities of ſea ſalt, which are abſorbed into the pores of water, when a given quantity is diſſolved in different quantities of water. The admiſſion of this principle hath drawn him into ſome concluſions which ſeem not quite conſonant to true philoſophy; as when he aſſerts that the quantity which is abſorbed into the pores, is not proportional to the number of the pores or the quantity of water: for, if a given quantity of water, ſuppoſe *A*, will abſorb a given quantity of any ſalt, ſuppoſe *a*, I can ſee no poſſible reaſon why *m A* ſhould not abſorb *m a*: for imagining *m A* to be divided into portions reſpectively equal to *A*, and equal quantities of ſalt to be diſſolved in each of them; then, from the ſuppoſition, each of them will abſorb *a*; and when they are all mixed together, as no precipitation will enſue, the ſum, or *m A*, muſt have abſorbed *m a*. But I have no inclination to animadvert upon what ſeems to be a ſmall miſtake of an author, whoſe various writings do much honour to philoſophy in general, nor to involve myſelf in a diſpute with any one. The following experiment may perhaps be thought concluſive againſt the doctrine of ſalts being abſorbed into the pores of water: I took a large glaſs receiver, containing near ſix gallons; into its neck, by means of a hole bored through a cork, I cemented a ſmall glaſs tube; and having filled the whole up to the middle of the tube with water, I dropped in a piece of ſea ſalt, weighing leſs than one forty thouſandth part the weight of the water: the water inſtantly roſe in the tube, continued ſinking during the ſolution, but at laſt remained as much elevated as it would have been had there been no more water than what would have been ſufficient to diſſolve it. In making this experiment, the receiver ſhould not be touched by the hand, for its parts ſuddenly expanding themſelves occaſion an inſtantaneous ſinking of the water in the tube, as I have frequently experienced, and might thus induce a ſuſpicion of the water's not being elevated by the addition of ſalt. I would not be underſtood from theſe experiments to deny the poroſity of water, ſince philoſophers have thought that the paſſage of light through it, and other phænomena indicate the exiſtence of vacuities in it; but I cannot believe, however ſolution be carried on, that the ſmalleſt quantity of ſalt can be diſſolved in the largeſt quantity of water, without increaſing its magnitude. The cauſe of the water's ſinking during ſolution doth not appear to be ſo certain; the eſcape of air, to which all the appearances induced me to refer it, and to which it may perhaps ſtill be owing, ſeems to be liable to ſome objections, not only from the experiments I have before mentioned, but from the following.

EXPERIMENT XII.

I took two matraſſes of equal dimenſions, one filled with common water, the other with boiled water. I poured into them equal quantities of oil of vitriol; in the firſt there ſeemed to be an univerſal precipitation of air, as it were, from every particle of the fluid, which, by little and little, formed itſelf into larger bubbles, and, aſcending through the neck, eſcaped; in the other, hardly any air could be obſerved, the water ſunk during the ſolution of the acid very apparently, yet $\frac{1}{1000}$th part of the water's weight of acid cauſed a ſenſible elevation: ſo that, whatever may be thought of the cauſe of the water's ſinking during the ſolution of a ſalt, the principle of its being to a certain degree imbibed into the pores of water ſeems in no caſe to be true, whether the ſalt be in a concrete or fluid form. This ſubject may receive ſome illuſtration from what is obſerved in the freezing of water; ice from common water is always ſpecifically lighter than water, from its retaining in its concrete form ſeveral air-bubbles, which enlarge its bulk without adding to its weight; this ice, when put into a matraſs, after the manner in which all the preceding experiments with ſalts were made, would elevate the water moſt upon the firſt immerſion: the water would ſink as the ice melted; equal portions of ice would produce equal elevations both before and after ſolution; the air would be ſeparated in a form more or leſs viſible, according to the circumſtances in which the experiment ſhould be tried; and not the ſmalleſt portion of ice could be diſſolved without increaſing the bulk of the whole. Salts do not ſeem to differ much from ice in the manner of their formation, and as ſimilar phænomena attend their ſolution in water, why may we not explain them from the ſame cauſe? But if any one ſhould think differently, notwithſtanding the experiments which have been produced, I profeſs myſelf extremely ready to liſten to any reaſoning founded upon experiment which may tend to prove my opinion to be erroneous; having no partiality for any thing but truth, nor being aſhamed of ignorance or miſtake in any matter, reſpecting the comprehenſion or explication of even the minuteſt operation of nature: *ego quidem hoc ſum contentus, quod licet quo quidque fiat ignorem, quid fiat intelligo.*

[This Eſſay has had a flattering attention paid it by foreigners; I know it has been tranſlated into the French, and I believe it has been tranſlated into the German language.]

THE following Eſſay was written near twenty years ago; a few copies of it were printed, but not publiſhed, in 1771: it was animadverted on by the late Doctor Hawkeſworth in the Gentleman's Magazine, by the authors of the Journal Encyclopedique, and in ſome other periodical publications about that time. There is a ſpeculation advanced in it relative to the perceptivity of vegetables, which I would not be thought to maintain with any pertinacity, yet I am pleaſed to ſee that ſo able a writer as Dr. *Percival* has ſupported the ſame ſide of the queſtion.* Whether vegetables have or have not the faculty of perception, is one of the many queſtions which it is pleaſant to diſcuſs, but difficult to decide; the arguments in favour of the affirmative ſide are ſuch as rather invite aſſent than extort conviction.

The opinion which I have endeavoured to illuſtrate, has not, I find, that novelty to recommend or to diſgrace it, which, when I wrote the Eſſay, I thought belonged to it; it has been incidentally adopted by ancient and modern authorities of great weight: I will quote the words of four diſtinguiſhed authors to this purpoſe.

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* Mancheſter Mem. Vol. II. page 114.

Stobæus acquaints us, that *Plato* thought plants were living bodies, endued with ſenſation. His words are —Πλατων και τα φυτα εμψυχα ζωα. φανερον και απο τȣ σαλευεσθαι, και εντεταμενȣς εχειν τȣς κλαδȣς, και ταις επαγωγαις εικειν, και παλιν σφοδρως αναχαλασθαι και αισθητικα, ενια δε και λογικα.* —*Cardanus* expreſſes himſelf in the following terms: *Nobiliores metallicis plantæ ſunt, atque in his quædam ſenſus imago relucet. Etenim et odiſſe et amare plantas, et membra habere functionibus opportuna, ſatis clarum eſſe puto.* †—*Rurſus quæritur, quare in mari quædam plantæ ſentiant, in terra non? At hoc inferius exponetur. Igitur forſan in craſſo aëre aliquam plantam, quæ ſenſum habeat, et ſimilem carni imperfectæ,*

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* Stob. Ecl. Phyſ. L. i. p. 87.

† Cardan. de Subtil. L. iii. de Plantis.

qualis eſt cochlearum et piſcium, non erit impoſſibile.[*]

The words of *Ray* are very remarkable—*Facultas ſentiendi animalibus tam propria cenſeri ſolet, ut eorundem differentia eſſentialis a philoſophis conſtituatur. Verum plantæ nonnullæ* Æſchynomenæ *veteribus dictæ, recentioribus* vivæ, *et* ſenſitivæ, *et* minoſæ, *haud obſcura, ſenſus indicia produnt.* He then mentions the moſt remarkable motions obſervable in ſenſitive plants, and aſks, *Quomodo hæc fiant, ſi ſenſum omnem et motum* ſpontaneum *iis denegemus mechanica aliqua ratione explicare perdifficile eſt?* †

Laſtly, the animal nature of vegetables is acknowledged as probable by *Spallanzani*, who is juſtly eſteemed the greateſt naturaliſt of the preſent age. Having remarked that *Haller* was the firſt who ſhewed that in birds the fœtus exiſts before fœcundation, and that he himſelf extended the diſcovery to different ſpecies of amphibious animals, and to ſome ſorts of plants, he adds, "Hence we have a new and ſtriking point of analogy between plants and animals to be added to the many others long known; and hence the ſuſpicion that theſe two tribes of organized bodies compoſe, perhaps, but one immenſe family, receives ſtrong confirmation." *

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[*] Id. de Rer. vari. L. vi. c. 22.

† Ray. Hiſt. Plan. Tom. I. l. 18.

It would be diſingenuous to conceal the ſentiments of thoſe who think that perception does not in any degree belong to plants; I will lay before the reader ſome authorities on this ſide of the queſtion, that the weight of the argument, *ad verecundiam*, may be equal on both ſides.

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* Diſſert. on the Nat. Hiſt. of Anim. and Veget. by Abbè Spallanzani. Engl. Tranſ. Vol. II. p. 315.

Sir John Hill, in his Vegetable Syſtem, places the difference between vegetables and animals in a ſyſtem of nerves which belongs to animals, but not to vegetables: "Vegetables," ſays he, "are placed by nature in a middle ſtate, between the mineral and the animal claſſes: ſuperior to the mineral in having organized bodies, inferior to the animal kinds in wanting a nervous ſyſtem. They are capable of growth, but below ſenſation. *

M. *Gleditſch* ſays—*Les plantes appartiennent à la claſſe des corps vivans*

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* Hill's Veg. Syſ. B. II. p. 1.

dans la nature. Elles ont leur ſtructure exactement règuliere, tout comme les animaux, avec leſquels elles ont beaucoup de reſſemblance par rapport a leur génération. Une des principales proprietès, celle que nous nommons l'irritabilité, leur eſt pareillement commune; mais pour l'autre, ſavoir la ſenſibilitè, elle demeurera toujours propre aux animaux.[*]

The opinion of *Haller* is thus expreſſed—By irritability, M. de *Haller* means, that property which certain parts of living bodies poſſeſs, of contracting when wounded, or even when touched, independent of the will of the animal that is ſubject to the experiment, and without its feeling any pain. A property which plants ſeem alſo to partake, and which being diſtinct from ſenſibility, does not depend on the ſame organs. He endeavours to prove, that irritability reſides excluſively in the muſcular fibres, and ſenſibility in the nerves. *

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[*] L'Acad. des Scien. Berlin, 1765. p. 52.

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* Memoirs of Haller, by Tho. Henry, p. 72.

ESSAY III.

On the Subjects of Chemiſtry, and their general Diviſion.

ALL terreſtrial exiſtencies may, in one view or other, be conſidered as the ſubjects of Chemiſtry: they are uſually divided into three diſtinct claſſes, called the three kingdoms of nature; the firſt includes Minerals, the ſecond Vegetables, the third Animals. Natural hiſtory, in an extended ſenſe, comprehends the knowledge of whatever relates to terreſtrial exiſtencies, excluſive of the moral actions of man, which conſtitute the baſis of civil hiſtory; and of the phyſical actions of bodies one upon another, which are the foundation of natural philoſophy.

Mineralogy is that part of natural hiſtory which treats of whatever is found upon the ſurface, or dug out of the bowels of the earth, except animal and vegetable ſubſtances: ſome have excepted water alſo, and denominated that branch of ſcience which explains the properties of water, Hydrology. And indeed, many chemiſts have thought proper to conſider water, as not appertaining to any of the three kingdoms of nature; but it hath no better right to be diſtinguiſhed from a ſolid, elaſtic, diaphanous mineral, than a melted metal hath to be diſtinguiſhed from the ſame metal when concreted into a ſolid form: in their different ſtates of fluidity and ſolidity they will have different properties; but ſhould not, from ſuch accidental changes as are effected by minute variations of heat, be referred to different claſſes: had water been called melted ice, no one would have ſcrupled to conſider it as belonging to the mineral kingdom.

The reducing quickſilver into a ſolid, malleable metal, by a due degree of cold, was an important diſcovery in phyſics: we learn from thence to conſider all fluid bodies, ſuch as water, oils, ſpirits, æthers, and probably the air itſelf, as convertible into ſolids without the introduction of any frigorific particles, but ſimply by a diminution of heat; and all ſolid bodies, as convertible into fluids, without ſuffering any other change in their conſtitution, except what ariſes from the volatilization of ſuch of their principles,

ciples, as cannot ſuſtain the degree of heat requiſite to render the reſt fluid.

Mineralogy is principally employed in arranging ſimilar bodies under the ſame, and diſſimilar bodies under different denominations. It judges of ſimilarity two ways; either from the ſimilarity of the external appearance, or from the ſimilarity of the internal conſtitution. The knowledge of the ſimilarity of the internal conſtitution of bodies is acquired, chiefly by regarding the changes produced in them by the action of fire, or the action of menſtruums; that of the external appearance by regarding the colour, configuration of the ſuperficial parts, conſiſtency, and weight. From the knowledge of the conſtituent parts of bodies is derived their œconomical application, their uſe in medicine, agriculture, metallurgy, and other arts: from the ſimilarity of the external appearance, is derived a ſuſpicion concerning the identity of the internal conſtitution; a ſuſpicion, ſerviceable in ſuggeſting conjectures to philoſophic minds, relative to the generation, tranſmutation, and deſtruction of natural bodies.

Moſt mineraliſts have contented themſelves with claſſing the various ſpecies of foſſils according to their moſt obvious qualities, and have thereby referred things very heterogeneous to the ſame genus. In the animal and vegetable kingdoms, the external appearance is of eſſential uſe in helping us to reduce them into genera and ſpecies: indeed, when from a reſemblance in one or two particular parts of a plant or an animal; as from the figure of the leaves, or the number of ſtamina; from the ſhape of the hoof, or the number of teeth, we venture to arrange them under the ſame general denomination, great confuſion will ariſe, if we ſuppoſe that general denomination to infer a reſemblance more extenſive than the idea from whence it was derived; nature often admitting a ſimilarity in ſome particulars, coexiſtent with the greateſt diſſimilarity in others: it is not probable however, that *Linnæus* in claſſing the productions of nature ever entertained ſuch a ſuppoſition, and he ſeems therefore to have been uncandidly cenſured. But when the whole external appearance of a plant, or an animal, is taken into conſideration, it is far eaſier to refer it to a particular claſs, than from a chemical inquiry into its internal conſtitution. In fact, the internal conſtitution depends, in a great meaſure, upon the ſame principle from which the external figure is formed. From the configuration of the vaſcular ſyſtem, through which nutrition is conveyed to every part of a plant or an animal, is derived the external figure; and from the ſame configuration the internal properties ſeem to ariſe: for plants become aceſcent or alcaleſcent, ſweet or bitter, poiſonous or ſalubrious, according to their different natures, though they be planted in the ſame ſoil, and fed with the ſame food, that being changed and elaborated, by proceſſes which we can neither underſtand nor imitate, into different fluids by the different organizations, and, I had almoſt ſaid, digeſtive powers of different plants. The caſe is quite otherwiſe with reſpect to minerals, the external appearances conveying to us little real knowledge; they may be the ſame in different bodies, or different in the ſame body.

Sir Iſaac Newton has proved, that the colours of natural bodies depend upon the thickneſs and denſity of the component parts, and conſequently that minute changes in either of theſe qualities will make very conſiderable changes in the colour: this philoſophy is confirmed by, and ſerves at the ſame time to explain, many appearances in chemiſtry. Cryſtals of quickſilver in *aqua fortis*, are white, yellow, or red, according to the degree of heat to which they have been expoſed; whilſt on the other hand, the ſame quickſilver corroded into a ſaline maſs by oil of vitriol, remains perfectly white in all degrees of heat, but by the affuſion of water is changed at once into a vivid yellow, which is of different ſhades according as the water is hot or cold, or as the maſs hath been more or leſs freed from its adhering acid by calcination. Iron and lead, and moſt other metals, undergo ſimilar changes of colour from calcination and precipitation, ſo that nothing ſeems more uncertain than the claſſing of bodies from a reſpect to their colour. This uncertainty of colour, according as the heat is various, is much felt and complained of by enamellers, and the makers of artificial gems.

The configuration alſo of the ſuperficial parts is a very uncertain characteriſtic of the ſpecific nature of a mineral: metallurgiſts are ſenſible of this; they are obliged in many caſes to have recourſe to fire, before they can pronounce concerning the metal contained in an ore, whether it be lead or ſilver, iron or antimony. We have a notable inſtance of this uncertainty in what is called the ſtellated regulus of antimony; the cryſtallization on the ſurface reſembling the radiations of a ſtar, the ſcales of a fiſh, branches of trees, fibrillæ of feathers and other matters, according to certain diverſities of circumſtances attending the proceſs. I do not deny but that a definite degree of liquidity in the *regulus* and *ſcoria*, a definite quantity and quality of the *ſcoria*, and a proper preciſion in ſome other matters, would ever produce a definite arrangement of the ſuperficial parts; but it is certain that a ſmall variation in any of theſe will make a great change in the outward and inward appearance of the regulus, without affecting in any ſenſible manner its internal compoſition. Another inſtance will ſhew the imperfection of this external method of claſſification ſtill more obviouſly: in ſeveral portions of water let there be diſſolved nitre, ſea ſalt, alum, borax, ſugar, ſaccharum ſaturni, corroſive ſublimate, &c. or any combinations of theſe ſalts, the ſeveral ſolutions will ſtill be equally colourleſs and tranſparent, and by a ſufficient degree of cold ſuddenly applied would be concreted into ſolid bodies, not to be diſtinguiſhed from one another by their colours, figures, conſiſtencies, nor (ſo the experiment might be managed) ſpecific gravities.

By theſe inſtances from chemiſtry, we can apprehend how there may be a perfect ſimilarity in the external appearances of bodies, when their internal conſtitutions are wholly different, and a diſſimilarity, when they are wholly the ſame. The minerals produced by nature are analogous to theſe of art, and hence we may infer the great confuſion and obſcurity which muſt neceſſarily attend a natural Hiſtory of Minerals, when it is founded only on the external appearance.

Senſible at laſt of this imperfection, the compoſers of ſyſtems of mineralogy have availed themſelves of the aſſiſtance of chemiſtry, and have endeavoured to claſs minerals according to their internal properties. This method is perfect in its kind; and in particular inſtances deſerves greater or leſs attention, according as the analyſis of minerals is more or leſs complete: in many caſes however it is too general and abſtracted for common uſe. For inſtance, all earths or ſtones which by a certain aſſignable degree of heat, and with a certain quantity of ſaline additions, are convertible into glaſs, may be called vitrifiable earths; all earths or ſtones which in the ſame degree of heat, and with the ſame quantity of ſaline additions, or without them, are not convertible into glaſs, but into quicklime, may be called calcareous earths; and all earths or ſtones which under ſimilar circumſtances remain unaltered in their properties, may, with reſpect to the other two kinds, be called refractory earths. This is all we can learn from chemiſtry relative to the comparative natures of earths, when expoſed to a given degree of heat; and hence fiſh-ſhells, chalk, limeſtones, and marbles would be included in the ſame claſs: but to anſwer the purpoſes of common life, it will be neceſſary to make a more particular diviſion of them, which can only be done after the generic idea hath been eſtabliſhed, by contemplating the external appearances; in which view the colour or figure, or both together, would be principally reſpected; as in fact we ſee they are in the diſtinction of the Italian *Antico's* as *Marmore Nero*, *Giallo*, *Roſſo di ſan guiſto*; *di Fiorenza*, *Pæſino*; *Alberino di Monte Gallicano*, &c. all of which are convertible into quicklime, but from their different colours, ſuperficial contextures, and capabilities of receiving different poliſhes, they have become of different values in a commercial light, and therefore are not improperly diſtinguiſhed in a ſyſtem of mineralogy. In like manner, though a chemical examination by fire would probably refer diamonds, emeralds, rubies, topazes, and other ſtones generally denominated precious, to the claſs of flints; yet ſince men have annexed a fanciful value to theſe pebbles from their pellucidity, colour, hardneſs, and other external attributes, it would be a great defect in a mineral ſyſtem not to have them particularly ſpecified and deſcribed.

But to diſcriminate common limeſtones, or common flints into different ſpecies, from a minute variation of the figure or the colour; to claſs pyrites, or combinations of ſulphur and iron, under the ſpecific denominations of ſpherical, hemiſpherical, pyramidal, cubical, &c.; to divide, as is uſually done, the ores of the ſame metallic ſubſtance into a great variety of kinds, when an aſſay will give no difference either in the quantity or quality of the metal contained in them, or of the matter by which they are mineraliſed, ſeems to be a multiplicatio entium præter neceſſitatem, and tends rather to obſcure and circumſcribe, than to elucidate and extend our knowledge of nature.

Upon the whole, the great outlines and general diviſions of mineral productions may moſt uſefully be made from a chemical inveſtigation of their conſtituent parts, and where it is expedient for commercial purpoſes to be more particular, an attention to the external appearance will be proper for that end. A mineraliſt who conſiders gypſeous alabaſters, plaſter ſtone, lamellated gypſums, rhomboidal ſelinites, *ſpatum Bononienſe*, and a great many other bodies as proper to be diſtinguiſhed from one another, and who is able to aſcribe any particular body to its proper ſpecies from conſidering its external appearance, is poſſeſſed of a particular kind and degree of knowledge: He who beſides being acquainted with the external appearances, is able to prove that all theſe different bodies are compoſed of a calcareous earth, united to the vitriolic acid; and thus make ſeveral ſpecies of things coaleſce together, and unite, as it were, under one general conception, hath a knowledge of theſe bodies different in kind, and ſuperior in degree. By this ſort of knowledge the memory is much relieved, and the mind, ever graſping after univerſal truths, is gratified with the acquiſition of general ideas. Theſe two very different kinds of knowledge belong to every part of mineralogy, in different views each of them is of indiſpenſable uſe, and a perfect ſyſtem of mineralogy ſhould include them both.

If it be aſked what are the diſcriminative characteriſtics of minerals, vegetables, and animals, as oppoſed to one another, I plainly anſwer that I do not know any, either from natural hiſtory or chemiſtry, which can wholly be relied on.

Syſtematic diſtinctions, and ſpecific diviſions of things, are uſeful in enlarging the comprehenſion of the mind; by methodizing the objects they ſeem to extend the boundaries of knowledge: but having no real foundation in nature, they ſhould not be depended on too far; they often perplex or impede the progreſs of a curious inquirer. This prepoſſeſſion in favour of ſyſtematic arrangements, operates more forcibly upon us as the ideas to which it is uſually annexed become the more abſtracted. The ſtrongeſt analogies are overlooked, the plaineſt reaſonings thought fallacious, and deciſive experiments inconcluſive, when their tendency is to ſubvert a diſtinction, of which we had wrongly ſuppoſed Nature herſelf the author. Every one thinks that he knows what an animal is, and how it is contradiſtinguiſhed from a vegetable, and would be offended at having his knowledge queſtioned thereupon. A dog or a horſe, he is truly perſuaded, are beings as clearly diſtinguiſhed from an herb or a tree, as light is from darkneſs; yet as in theſe, ſo in the productions of nature, the tranſition from one to the other is effected by imperceptible gradations.

The loco-motive powers which appertain to moſt animals, whether they proceed from the *Carteſian* mechaniſm, or from ſenſation, are ſo manifeſt in quadrupeds, birds, fiſhes, and inſects, that in our firſt and ſuperficial inquiries into nature, we are apt to conſider the poſſeſſion or want of theſe powers, as making a deciſive and eſſential difference between animal and vegetable bodies; and it is not without a certain degree of regret, as it were, that we find ourſelves obliged to predicate animality concerning a great variety of beings, which are deſtitute of every power of progreſſive motion. If at the ſame time we happen to have entertained ſome preconceived opinions, no matter whence they have been derived, concerning the uſual ſhapes of animals, (tho' they are far more different from one another than ſome of them are from vegetables) our repugnancy to the admitting a being of the outward form of a ſhrub, into the claſs of animals, is much increaſed. Hence have proceeded moſt of the objections which have been made to the fine diſcoveries of *Peyſſonel*, *Juſſieu*, *Ellis*, and others, relative to the animal nature of corals, madrepores, millepores, corallines, ſpunges, and a numerous tribe of bodies which the very ingenious labours of *Marſigli* had formerly removed from the mineral kingdom, where they had been placed by *Woodward* and other Mineraliſts, and allotted to that of vegetables.

If rejecting ſpontaneous motion and figure as very inadequate teſts of animality, we adopt perception in their ſtead; no doubt, he would be eſteemed a viſionary in Philoſophy who ſhould extend that faculty to vegetables; and yet there are ſeveral chemical, phyſical, and metaphyſical reaſons which ſeem to render the ſuppoſition not altogether indefenſible.

The greater the quantity of perception exiſting in the univerſal ſyſtem of creation, the greater is the quantity of happineſs produced; and the greater the quantity of happineſs produced, the greater is the goodneſs of the Deity in the eſtimation of beings with our capacities. The latter part of this propoſition needs no proof; and the former is liable but to one objection, and that grounded upon a falſe ſuppoſition. If, it may be urged, all the ſpecies of percipient beings be not accommodated with objects congruous to their faculties of perception, and productive of more pleaſure than pain to the whole ſpecies taken collectively, then the animation of that matter of which they conſiſt is an introduction of evil, and no teſt of benevolence. This may be granted; but in all the ſpecies of beings which come within the obſervation of our ſenſes, the ſuppoſition of their not being furniſhed with objects ſuited to their wellbeing is evidently not true.

true, and therefore ought, from analogy, to be rejected with reference to ſuch as by their magnitude, their minuteneſs, or their dulneſs of perception eſcape our examination.

That animals ſhould feed one upon another, is a law of nature full of wiſdom and goodneſs, life and happineſs being indefinitely multiplied thereby. For a given quantity of what are called vegetables, annually produced upon a globe of a given diameter, being ſufficient but for the ſupport of a given number of herbaceous animals, whoſe place in the univerſe not admitting their immortality, it hath been wiſely contrived that their bodies, which from their ſtructure muſt periſh, ſhould in ceaſing to live, become the inſtruments of ſupporting life in beings, which could not by any other means have had an exiſtence, at leaſt upon this globe; and of the other parts of the univerſe we know nothing except from analogy, and from that we muſt conclude that the τὸ πᾶν, be it finite or infinite, is as full of life as this particular part with which we are connected. Nay, animated matter, containing as it were the concentrated virtue of many vegetables, ſerves for the ſupport of life, and the conſequent communication of happineſs in a far more ample manner than vegetables themſelves; animal ſubſtances in equal weights furniſhing more nutriment than vegetable. It is by Death, a ſeeming imperfection in his workmanſhip, that the Deity preſerves vegetable life, ſupports the animal kingdom, daily regulates and renews the œconomy of nature, and continues this wonderful ſyſtem of things in full youth and vigour, not interrupted by diſeaſe, nor enfeebled by old age.

No objection therefore to the animality of vegetables can be brought from any conſiderations reſpecting their daily deſtrūction; for the deſtruction of animals by other animals, the *bellum omnium in omnia*, is an univerſal law of nature, derived from the ſame benevolence to which we attribute creation itſelf. If then every part of the vegetable kingdom hath a degree of perceptivity, however ſmall, there will be a gain of happineſs to the whole ſyſtem; the aggregate may be of a value not to be overlooked by him, to whom the exiſtence of all things is equally poſſible, and from whom all created exiſtences are equally diſtant in perfection.

Wherever there is a vaſcular ſyſtem, containing a moving nutritive *ſuccus*, there is life; and wherever there is life there may be, for ought we can prove to the contrary, a more or leſs acute perception, a greater or leſs capacity for the reception of happineſs: the quantity, indeed, of which after we have deſcended below a certain degree of ſenſibility, will (according to our method of eſtimating things, which is ever partial and relative to ourſelves) be ſmall in each individual; yet is the exiſtence of it in the nature of things poſſible, from the analogy of nature probable: and who can tell whether in a ſyſtem of nature, confeſſedly contrived for the production of the greateſt poſſible good, it may not alſo be neceſſary?

It ſhould be well weighed by the metaphyſicians, whether they can exclude vegetables from the poſſeſſion of the faculty of perception, by any other than comparative arguments; and whether the ſame kind of comparative reaſoning will not equally exclude from animality thoſe animals which are provided with the feweſt and the obtuſeſt ſenſes, when compared with ſuch as are furniſhed with the moſt and the acuteſt. The perception of a man (though it may be doubted whether there are not ſeveral animals which have all the ſenſes more acute) ſeems to be indefinitely greater when compared with that of corallines, ſea-pens, and oyſters, than the perception of theſe, which are allowed to be animals, doth when compared with the ſigns of perception manifeſted by a variety of what are called vegetables. Spunges open and ſhut their *mamillæ*, corals and ſea-pens protrude or draw back their ſuckers, ſhell-fiſh open or keep cloſe their ſhells in ſearch of food or avoidance of injury; it is from theſe and ſimilar muſcular motions that we judge the beings to which they belong to have perception, that is, to be animals. Now in the vegetable kingdom, we may obſerve the muſcular motions of many plants to be, to the full, as definite and diſtinguiſhable as thoſe of the claſs of animals juſt mentioned. The plants called *Heliotropæ* turn daily round with the ſun; by conſtantly preſenting their ſurfaces to that luminary, they ſeem as deſirous of abſorbing a nutriment from its rays, as a bed of muſcles doth from the water, by opening their ſhells upon the affiux of the tide. The *Flores Solares* are as uniform in their opening and ſhutting as animals are in their times of feeding and digeſting; ſome in theſe motions do not obſerve the ſeaſons of the year, but expand and ſhut up their flowers at the ſame hour in all ſeaſons; others, like a variety of inſects which appear, or not, according to the heat of the weather or climate, open later in the day, or do not open at all, when they are removed from a ſouthern to a more northern latitude. Trefoil, woodſorrel, mountain ebony, wild ſenna, the African marigold, &c. are ſo regular in folding up their leaves before rainy weather, that they ſeem to have a kind of inſtinct or foreſight ſimilar to that of ants; which however deſerts many of them as ſoon as they have propagated their kind, by ſhedding their pollen. Young trees, in a thick foreſt, are found to incline themſelves towards that part through which the light penetrates, as plants are obſerved to do in a darkened chamber towards a ſtream of light let in through an orifice, and as the ears of corn do towards the ſouth. The roots of plants are known to turn away with a kind of abhorrence from whatever they meet with which is hurtful to them, and to deſert their ordinary direction, and to tend with a kind of natural and irreſiſtible impulſe toward collections of water placed within their reach: many plants experience convulſions of their *ſtamina* upon being ſlightly touched. Whatever can produce any effect upon an animal organ, as the impact of external bodies, heat and cold, the vapour of burning ſulphur, of volatile alcali, want of air, &c. are found to act alſo upon the plants called ſenſitive. But not to inſiſt upon any more inſtances, the muſcular motions of the *Dionæa Muſcipula*, lately brought into Europe from America, ſeem far ſuperior in quickneſs to thoſe of a variety of animals. Now to refer the muſcular motions of ſhell fiſh, and zoophytes, to an internal principle of volition, to make them indicative of the perceptivity of the being; and to attribute the more notable ones of vegetables, to certain mechanical dilatations, and contractions of parts occaſioned by external impulſe, is to err againſt that rule of philoſophyzing which aſſigns the ſame cauſes for effects of the ſame kind. The motions in both caſes are equally accommodated to the preſervation of the being to which they belong, are equally diſtinct and uniform, and ſhould be equally derived from mechaniſm, or equally admitted as criterions of perception.

I am ſenſible that theſe and other ſimilar motions of vegetables may by ſome be conſidered as analogous to the automatic or involuntary motions of animals; but as it is not yet determined amongſt the Phyſiologiſts, whether the motion of the heart, the periſtaltic motion of the bowels, the contractions obſervable upon external impulſe in the muſcles of animals deprived of their heads and hearts, be attributable to an irritability unaccompanied with perceptivity, or to an uneaſy ſenſation, there ſeems to be no reaſon for entering into ſo obſcure a diſquiſition; eſpecially ſince irritability, if admitted as the cauſe of the motions of vegetables, muſt, *a fortiori*, be admitted as the cauſe of the leſs exquiſite and diſcernible motions of beings univerſally referred to the animal kingdom.

Phyſical obſervations concerning the generation, nutrition, organization, life, health, ſickneſs, and death of plants, help us as little towards the eſtabliſhing a diſcriminative characteriſtic between them and animals, as metaphyſical ſpeculations relative to the quantity of happineſs, or degrees of perceptivity.

The eaſtern practice of fœcundating the female palm tree by ſhaking over it the duſt of the male, which *Herodotus* mentions in his account of the country about *Babylon*, and of which Dr. *Haſſelquiſt* in the year 1750 was an eye witneſs, was not unknown to *Ariſtotle* and *Pliny*: but the ancients ſeem not to have carried the ſexual ſyſtem beyond that ſingle inſtance, which was of ſo remarkable a kind, that it was hardly poſſible for them to overlook it; at preſent there are few botaniſts in Europe who do not admit its univerſality. It ſeems generally agreed, that a communication of ſexes, in order to produce their like, belongs to vegetables as well as to animals. The diſputes ſubſiſting among the anatomiſts, concerning the manner in which conception is accompliſhed, whether every animal be produced *ab ovo femellæ*, or *a vermiculo in ſemine maris*, are exactly ſimilar to thoſe amongſt botaniſts concerning the manner in which the *farina fœcundans* contributes to the rendering the ſeed prolific: but however theſe doubts may be determined, they affect not the preſent inquiry, ſince it is allowed on all hands, that as the eggs of oviparous animals, though they arrive at their full magnitude, are incapable of being vivified by incubation, unleſs the female hath had commerce with the male: ſo the dates of female palm trees, and the fruits of other plants, though they ripen, and arrive at maturity, will not grow unleſs they have been fœcundated by the *pollen* of the male.

In like manner, notwithſtanding the diverſity of opinion which hath long ſubſiſted, and in a matter ſo little capable of being enlightened by experiment, probably ever will ſubſiſt, concerning the *modus agendi* by which nature elaborates the nutritive fluid, adminiſters it to the fœtus in the womb, and produces an extenſion of parts; yet ſince a *placenta* and an umbilical chord are by all thought eſſential to the effecting theſe ends; and ſince the cotyledons of plants, which include the *corculum* or firſt principle of the future plant, with which they communicate by means of tubes branched out into infinite ramifications, are wholly analogous to the placenta and umbilical chord of animals, we have great reaſon to ſuppoſe that the embryo plant and the embryo animal are nouriſhed and dilated in their dimenſions after the ſame way. This analogy might be extended and confirmed by obſerving that the lobes, within which the fœcundated germ is placed, are by putrefaction converted into a milky fluid, well adapted as an aliment to the tender ſtate of the plant.

Exſpiration and inſpiration, a kind of larynx and lungs, perſpiration, imbibition, arteries, veins, lacteals, an organized body, and probably a circulating fluid appertain to vegetables as well as to animals. Life belongs alike to both kingdoms, and ſeems to depend upon the ſame principle in both: ſtop the motion of the fluids in an animal limb by a ſtrong ligature, the limb mortifies beyond the ligature, and drops off; a branch of a tree under like circumſtances, grows dry, and rots away. Health and ſickneſs are only other terms for tendencies to prolong or to abridge the period of life, and therefore muſt belong to both

both vegetables and animals, as being both poſſeſſed of life. An eaſt wind, in our climate, by its lack of moiſture, is prejudicial to both; both are ſubject to be froſt-bitten, and to conſequent mortifications; both languiſh in exceſſive heats; both experience extravaſations of juices from repletion, and pinings from inanition; but can ſuffer amputation of limbs without being deprived of life, and in a ſimilar manner both form a *callus*; both are liable to contracting diſeaſes by infection; both are ſtrengthened by air and motion: *Alpine* plants, and ſuch as are expoſed to frequent agitation from winds, being far firmer and longer lived than thoſe which grow in ſhady groves, or hot houſes; both are incapable of aſſimilating to their proper ſubſtance all kinds of food;

for

for fruits are found to taſte of the ſoil, juſt as the urine, and milk, and fleſh, and bones of animals, often give indications of the particular *pabulum* with which they have been fed: both die of old age, from exceſs of hunger or thirſt, from external injuries, from intemperature of weather, or poiſoned food.

Seeds of various kinds retain their vegetative powers for many years: the vivification of the *ova*, from which the inſects occaſioning the ſmut in corn, and the *infuſoria animalcula* obſervable in water after the maceration of plants, probably proceed, may be eſteemed a ſimilar phænomenon. It is not yet clearly decided amongſt naturaliſts, whether the ſeeds of muſhrooms, of mucors, and of the whole claſs of *Fungi*, be not in a tepid, humid *matrix*, changed into vermicular animals, which loſe in a little time their power of ſpontaneous motion, coaleſce together, and grow up into theſe very ſingular plants: the quickneſs of their increaſe, and the irreſiſtible force with which the leaſt mouldineſs propagates itſelf, and deſtroys the texture of the bodies upon which it fixes, ſeem to point towards an animal nature.

Different vegetables require different ſoils, as different animals do different food for their ſupport and well being: aquatics pine away in dry ſandy grounds, and plants which love rocks and barren ſituations, where they imbibe their chief nutriment from the air, become diſeaſed and putrid in rich bogs and ſwamps.

There are aquatic animals which become immovable and lifeleſs when the rivulets in which they ſubſiſted happen to be dried up, but which recover their life and locomotive powers upon the deſcent of rain: in this circumſtance they are analogous to the claſs of moſſes among vegetables, which, though they appear to be dried up, and ready to crumble into duſt during the heats of ſummer, yet recover their verdure and vegetable life in winter, or upon being put into a humid ſoil.

Trembley, *Bonnet*, and *Spallanzani* have vaſtly amplified our views of nature; they have diſcovered to us divers ſpecies of animals, which may be cut into a variety of pieces without loſing their animal life, each piece growing up into a perfect animal of the ſame kind: the multiplication of vegetables by the planting of branches, ſuckers, or joints of roots is a ſimilar effect. The reproduction of the legs of craw-fiſh, lobſters, crabs, of the horns and heads of ſnails, legs of lizards, of the bony legs and tails of ſalamanders, when by accident or deſign they have been deprived of them; and the great difference in the time of the reproduction, according to the ſeaſon of the year in which the limb is loſt, are wonders in the animal kingdom, but wholly analogous to the repullulation of trees after lopping.

All plants, except thoſe of the claſſes *Monæcia* and *Diæcia*, are hermaphrodites; that is, they have the male and female organs of generation within the ſame empalement. Shell-fiſh, and ſuch other animals as reſemble vegetables in not being able to move far in ſearch of mates, with which they might propagate their kind, are hermaphrodites alſo: *Reaumur* hath proved that vine fretters do not want an union of ſexes for the multiplication of their kind.

From the conjunction of animals of different ſpecies are produced *hybrides*, which in many caſes cannot propagate: botaniſts have tried the experiment, and by fœcundating female flowers with the male duſt of another ſpecies, have produced hybridous plants, of an intermediate ſhape, the ſeeds of which are barren and effete.

Trees ſhed their leaves as birds do their feathers, and hirſute animals their hair. At particular ſeaſons the juices of vegetables move with fulneſs and vigour; at others they are leſs plentiful, and ſeem to ſtagnate; and in this they reſemble dormice, bats, frogs, and numberleſs other animals of cold blood, which lie torpid and deſtitute of every ſign of life during the winter time; the action of the lungs and of the heart being, if any, imperceptibly weak and languid.

Few, if any animals can exiſt without a reciprocal ſucceſſion of ſleep and vigilance, and the younger the animal, the greater is its propenſity to ſleep: the ſame alternatives ſeem neceſſary for the health of ſeveral vegetables; a great variety of plants fold up their leaves, and ſeemingly compoſe themſelves to reſt, in the night time, and this diſpoſition for ſleep is more remarkable in young plants than in old ones; nor does it, as might be ſuſpected, depend upon the influence of light or heat, ſince plants in hot houſes, where the heat is kept at the ſame degree, fold up their leaves at a ſtated time in the evening, and expand them in the morning, whether the light be let in upon them or not. It may deſerve to be inquired, whether by a relaxation of fibres theſe plants become ſubject to a more copious perſpiration during ſleep than in their ſtate of vigilance, as *Sanctorius* hath proved to be the caſe in animals.

There is a great diverſity, but a regular ſucceſſion in the times, in which animals of different ſpecies feel the *œſtrum*, by which they are ſtimulated to the propagation of their reſpective kinds; an order equally determined, is obſervable in the times of accompliſhing the *ſponſalia* of plants. The periods of incubation in oviparous, and of geſtation in viviparous animals are not more various in different ſpecies, nor probably more definite in the ſame, than the periods requiſite for the germination and maturation of different ſeeds. By the influence of heat and cold, abundance and ſcarcity of nouriſhment, the ſeaſons of propagating may be ſomewhat accelerated or retarded in animals as well as in vegetables: the effects of a cold ungenial ſpring are as remarkable in the retardation of the procreative intercourſes of birds and beaſts, as in the ſtoppage of the leaſing of trees, or the flowering of ſhrubs. In a word, there are ſo many circumſtances in which the anatomy and phyſiology of ſome plants agree with thoſe of ſome animals, that few, I believe, can be mentioned in which they diſagree.

When it is conſidered that animals are either mediately or immediately wholly nouriſhed from vegetables, it might be expected, *a priori*, that the products obtainable by a chemical analyſis from the two kingdoms ſhould be different rather in quantity than quality, and that we could not from thence diſcover any criteria by which they might be diſtinguiſhed from one another: this obſervation is confirmed by experiment. Animals, it is true, in general yield a greater proportion of a volatile alkaline, than of an acid ſalt by diſtillation; vegetables on the contrary abound in acid, and yield not any volatile alkali, unleſs with the laſt degree of heat, or when they have undergone putrefaction:

in ſaying this, I am aware that I differ from the opinion commonly received. Muſtard ſeed, water creſſes, horſe radiſh, and other plants of the *tetradynamia* claſs are generally ſaid to contain a volatile alkali already formed, and to yield it with the heat of boiling water; from none of theſe however could I ever obtain by that heat a phlegm which would give a precipitation with corroſive ſublimate, the moſt indubitable teſt of a fluid's containing even the minuteſt portion of volatile alkali; the pungent ſmell ſeems to have been miſtaken here, as *Sir John Pringle* hath well obſerved the *fœtor* to have been in the putrefaction of many animal ſubſtances, as proceeding from a volatile alkali; and which may, perhaps, be with greater truth attributed to a volatile oil, a ſmall portion of which is ſometimes procurable from pepperwort, by the heat of boiling water impregnated with ſea ſalt. However, as ſome animals, and ſome parts of moſt animals yield a portion of acid, and as moſt vegetables, by a ſtrong fire in cloſe veſſels, or when converted into ſoot, afford a volatile alkali, altogether ſimilar to that obtained from animal ſubſtances, we cannot from theſe circumſtances eſtabliſh any diſtinctive mark between the two kingdoms.

With reſpect to Minerals indeed, chemiſts think that they have found out an infallible and univerſal criterion, by which they may be diſtinguiſhed from every animal or vegetable ſubſtance. All bodies from which we can obtain an oil by diſtillation,

tillation, or otherwiſe, are ſuppoſed to belong to ſuch ſubſtances as have enjoyed an organic life; no mineral, it is ſaid, containing any: this is a ſenſible diſtinction, and yet it is not perhaps in extreme caſes wholly to be relied upon. When a vegetable or animal is diſtilled in cloſe veſſels, the ſtronger the fire is, the more oil is obtained; what firſt paſſes into the recipient is more clear and limpid than what comes over towards the end of the operation: it may be preſumed, however, that what remains adherent to the coal in the retort, and which no violence of fire can ſeparate, is not eſſentially different from the laſt portions which are diſtilled; yet this, be it fixed oil or phlogiſton, is no wiſe different from what enters into the compoſition of metallic ſubſtances, and of mi-

minerals, perhaps, of all kinds. Zinc burns with a flame reſembling that of charcoal; lead and tin burn like rotten wood; iron and other metals may be burnt to aſhes in the open air, but like charcoal cannot be decompoſed in cloſe veſſels; ſpirits of wine burn like ſulphur, charcoal and metallic ſubſtances without producing any ſoot; yet from ſpirits of wine an oil may be obtained: Why ſhould the phlogiſton of metals be thought of a nature wholly different from the oil which ſo obſtinately adheres to charcoal, or from that which ſeems to enter into the compoſition of vinous ſpirits?

Naturaliſts, as well as chemiſts, have perhaps too precipitately embraced the opinion, that minerals may be certainly and readily diſtinguiſhed from the other two kingdoms. A vaſcular ſyſtem, a nutritive ſuccus, and a power of producing its like, conſtitute the abſtract idea both of a vegetable and an animal, as contradiſtinguiſhed from a mineral: this idea is clear and definite in itſelf; but to determine how far the coexiſtence of theſe qualities is in the nature of things neceſſary, or where any of them ceaſes to exiſt, is a queſtion of vaſt difficulty when applied to particular caſes. Stones dug out of quarries, ores out of mines, in general, minerals ſeparated from their *matrices*, are like the dead branches or limbs of vegetables or animals, incapable of receiving increaſe, except from an external incruſtation; but whether the matrices themſelves increaſe, or that being in ſome caſes granted, whether they receive their augmentation from an external appoſition, or an internal aſſimilation and extenſion of parts, cannot readily be decided either way. In the *Cretan* labyrinth it hath been obſerved, that the names of travellers, which have been cut in the rock in former ages, are now in *alto relievo*, and that the older the dates are, the greater is the protuberance; reſembling the callus formed by inciſions in trees. In the mines of *Chremnitz* in Hungary, which have been wrought for above one thouſand years, the ancient roads which had been cut through the rocks are left to grow up; and it is remarked, that they approach one another in a horizontal, and not in a perpendicular direction; the ſame phænomenon may be obſerved in the marble quarries in *Italy*, as is mentioned by *Baglivy* in his Treatiſe upon the Vegetation of Stones: but whether theſe, and many ſimilar appearances are to be attributed to the preſſure of the ſuperincumbent ſtrata, or to a kind of vegetable growth, is a doubtful point. Rock cryſtals, amethyſts, and various precious ſtones have been thought by *De Boot* and others to grow like muſhrooms; certain it is, that they often contain in them ſeveral heterogeneous particles; a circumſtance which proves them to have been once in a fluid ſtate, and induces a ſuſpicion that in their formation they may reſemble the gums and reſins extravaſated from various ſpecies of vegetables. The vegetation of ſtones hath been admitted by many, and ſome have contended that minerals, as well as animals and vegetables, ſpring from ſeed, the greateſt rock being nothing but the expanſion of the parts of a minute grain of ſand.

Salts diſſolved in water conſiſt of indefinitely ſmall *moleculæ*, which, as far as microſcopes can inform us, are ſimilar in figure to the large cryſtals which become viſible to the naked eye, and which are formed, as it were, from the expanſion of one particle: it will be eaſily underſtood, how conformable this mineral cryſtallization is to the opinion of thoſe, who attribute the growth of animals and vegetables to the *accretion of organic particles* of the ſame kind. The concentrick cruſts of which *ſtalactites* conſiſt, are not either in their appearance, or their formation, perhaps, unlike the circles annually produced by the ſtagnation of the ſap in the boll and branches of trees. The native gold and ſilver tufts, which appear to burſt through the hardeſt rocks, and which from their great reſemblance to trees, have been called by ſome arboreſcent, ſeem to indicate a kind of vegetation in their formation.

Suppoſing, however, that we pay no attention to any of theſe circumſtances, yet cannot we form any judgment concerning the internal ſtate of the earth. The greateſt depths to which Miners have penetrated even in mountainous countries, which may be conſidered as excreſcencies from the true ſurface of the earth, or the level of the ſea, have ſcarcely ever equalled one ſixteen thouſandth part of its diameter; a diſtance altogether inſufficient for the forming any probable conjecture about the inward conſtitution of the globe. The *ſtrata* of ſtones, and veins of minerals, which are met with upon the ſurface, can give us as little information concerning the internal ſtructure of the earth from which theſe are probably derived, as the contemplation of the ſcales of a fiſh, the feathers of a bird, or the *Epidermis* of a man, would concerning the bones and muſcles, the veins and arteries, the circulation of the blood, and the ſeveral ſecretions of an animal body. Many minerals ſeem in their formation to have been antecedent, others ſubſequent to the univerſal deluge; a great part of the matter conſtituting the outward ſhell of the earth, the only part which we can examine, hath been ſubſervient to vegetable or animal life. All the *ſtrata* of limeſtones, chalks, marbles, all gypſums, ſpars, alabaſters, &c. are confeſſedly of animal origin. The *ſtrata* of pit-coal, and of all bituminous foſſils, of ſome ſpecies of ſlates, whatever may be thought of argillaceous ſtrata in general, the mould every where covering the ſurface of the earth, and other ſubſtances, are ſuppoſed, probably enough, to have ariſen from the deſtruction of vegetables; ſo that I know not whether it would be a very extravagant conjecture which ſhould ſuppoſe that all matter is, or hath been organized, enlivened, animated.

Hence may it appear probable, with reverence yet, and conſcious ignorance be it ſpoken, that the *One*, *Eternal*, *Incomprehenſible God* hath eſtabliſhed an uninterrupted concatenation in all his works, which he hath ſubmitted to our view. Different individuals hath he mingled together into the ſame *ſpecies*; different ſpecies into the ſame *genus*; different *genera* into the ſame kingdom; and different kingdoms he hath diſtinguiſhed, perhaps, but by lines of diviſion too minute for our obſervation. This ſtrong analogy by which men and minerals, and all intermediate exiſtencies are bound together in a common chain, and thence, it would ſeem, naturally ſubjected to a common fate, may appear humiliating to ſuch as have been wont to entertain high notions of the phyſical dignity of human nature: but it cannot offend nor diſquiet thoſe, who feel within themſelves faculties eſſential to the conſtitution of moral agency, and who from thence become capable at leaſt of retribution;

of puniſhment, or reward in another ſtate.

In the number of our ſenſes, and in the modifications of the intellectual faculties which ſpring therefrom, we have a great reſemblance to many animals which inhabit this planet as well as we. The *genus* to which man belongs includes a great many ſubordinate *ſpecies*; or, to ſpeak in a manner more conformable to nature, and more conſonant to the account we have of its origin, the human ſpecies, from the diverſities of climate and of food, from changes introduced by diſeaſe, and continued, perhaps, by propagation, and from other cauſes which are unknown to us, hath been branched out into a great many varieties: theſe, however, are as much diſtinguiſhed in ſhape and intellect from one another, as they are from animals which have ſprung from a different ſtock. Anatomiſts, *whether they conſider the brain as an inſtrumental, or an efficient cauſe of intelligence*, are agreed in acknowledging a great reſemblance between the contents of the human *cranium* and thoſe of quadrupeds; and *Putius* hath proved, contrary to the opinion embraced by *Pliny*, and commonly received, that we have not that medullary ſubſtance in a greater proportion than other animals. Nor are we characterized by a circumſtance generally eſteemed eſſentially neceſſary to the ſupport of the human fœtus, and excluſively appertaining to our ſpecies: nations are mentioned to whom it doth not belong, and whatever degree of credit may be given to that narration, it is certain that a great many ſpecies of animals have been diſcovered to which it doth. Notwithſtanding this analogy by which we are to be claſſed with the reſt of the animals around us, yet hath it pleaſed Him who called forth from nothing both us and them, and thankful we ought to be for the preference, to place us at the top of the ſcale, to make us, as it were, the firſt term of a ſeries, deſcending indefinitely by imperceptible gradations, to particularize that claſs of animals to which we belong, by rendering it capable of forming a moral character. This capability, it is true, is various according to the opportunities of, and capacities for receiving inſtruction in different ſpecies, and in different individuals of the ſame ſpecies: the Orang-outang of the woods of Java, the apron-bellied Caffre of the Cape*; the woolly-headed Negro of Africa, the beardleſs Savage of America, the dwarfiſh Inhabitant of the Frigid Zone, the moon-eyed Albino, and the enlightened European, are as different from one another in this circumſtance as in outward form: yet wherever it exiſts even in the ſmalleſt degree, there ariſeth a proportionable imputability of conduct, a kind of title to the natural or covenanted good, a reaſonable ſubjection to the natural or poſitive evil, which God hath annexed as ſanctions to the laws which he hath thought fit to preſcribe for the regulation of the moral conduct of mankind.

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* Since the writing of this Eſſay it has been diſcovered by Profeſſor *Sparmann*, that the epithet here applied to the Caffres, on the authority of former Voyagers, is not juſt; and it is now alſo believed, on good authority, that the Savages of America would reſemble Europeans in having beards, if they did not pluck out the hairs by the roots as ſoon as they begin to appear. If the reader wiſhes to ſee an account of the principal varieties of the human race, he may conſult *Van Berchem's Tableau*, publiſhed in the Memoires de Lauſanne, 1783.

ESSAY IV.

Some Remarks on the Effects of the Cold in February, 1771.

ON the 12th of February, 1771, about an hour after ſun riſing, I obſerved at Cambridge a degree of cold which is very unuſual in England, though common enough in more northern climates. *Fahrenheit*'s thermometer, made by *Dollond*, as well in the open air, as when covered with ſnow, ſtood as low as 6° above 0. The *Cam*, by no means a rapid river, remained unfrozen; at the ſides indeed there was a little ice, and ſome ſmall flakes floating in the middle. This is no very uncommon phænomenon. The *Seine* was not frozen at *Paris* in 1709, though the cold continued for two days one degree greater than in the preſent caſe. Various reaſons have been produced, in order to account for this ſeeming deviation from the uſual courſe of nature. It hath been generally believed, that the ſtrong current in the *Seine* impeded the congelation: motion will certainly hinder the parts of fluid bodies from acquiring a regular arrangement; but it may be doubted whether it will wholly prevent their coaleſcence, in any caſe where the degree of heat is leſs than what would keep them fluid if they were quieſcent. We have frequent inſtances in chemiſtry, of ſaturated ſolutions of ſalts remaining perfectly fluid whilſt at reſt, and of forming thick coagulums upon the leaſt motion. Melted metals, glaſs, reſins, &c. appear to continue fluid for a longer time, after being taken from the fire, by having their parts moved, than if they are left at reſt; becauſe the ſuperficies which is expoſed to the air is conſtantly changing, and the whole maſs becomes uniformly cold and fixed at once, as ſoon as it has parted with the heat neceſſary for its fuſion. The moſt rapid rivers would probably experience a ſimilar change, did the cold in the atmoſphere continue long enough to be communicated to the whole body of the water: for upon taking the thermometer out of the ſnow, which laid upon the bank of the river, and immerſing it into the water, it ſuddenly roſe 26°, and ſtood at 32°, or higher; ſo that the air was very conſiderably colder than the water: nor is this at all to be wondered at, when we conſider that great degrees of cold may be ſuddenly produced in the atmoſphere by cauſes which do not immediately operate upon other bodies. Thus the influx of colder air from the northern latitudes, or the deſcent of that which always remains exceedingly cold in the upper parts of the atmoſphere in the ſame latitude, may in a few hours wholly change the air of a particular diſtrict: or, if from any peculiar circumſtance the air ſhould become unuſually dry, and conſequently diſpoſed to diſſolve much water, a great degree of cold might be almoſt inſtantaneouſly produced; but which could not be communicated to other bodies, in a little time, by ſo rare a fluid as the air.

During the forementioned degree of cold, a thick vapour was ſeen riſing from the ſurface, and marking as it were the courſe of the river. If we attribute the elevation of this vapour to the attraction of the air, rather than to the comparative warmth of the water (for water juſt beginning to freeze is obſerved not to loſe of its weight by evaporation *in vacuo*), the great cold may be thought perhaps to have proceeded from the ſolution of water in air which was then carrying on; for the earth was glutted with humidity, and the air was become dry, having been freed from its water by an almoſt inceſſant precipitation for three days, under the form of ſnow or ſleet. It is very remarkable, that the extreme cold of January 13, 1709, came on at *Paris*, with a gentle ſouth wind, and was diminiſhed when the wind changed to the north; this is accounted for by M. de la *Hire*, from the wind's having paſſed over the mountains of *Auvergne* to the ſouth of *Paris*, then covered with ſnow; and by Mr. *Homberg*, from the reflux of that air, which had been flowing for ſome time from the north. I do not ſee from what philoſophical principle it can be ſuppoſed, that the ſame air in its regreſs from a ſouthern latitude ſhould be colder than in its progreſs from a northern; and as to the other opinion, the phænomenon of the cold's increaſing upon the wind's changing from north to ſouth, hath been taken notice of in other places, where there was no ſnow to refer it to. May it not deſerve to be conſidered, whether the ſudden ſolution of large quantities of aqueous vapours, brought from the ſouth into a dry northern air, be not a cauſe adequate to the effect produced? The ſolubility of water in air is diſtinctly mentioned by Dr. *Halley*, in the Philoſ. Tranſ. N° 192; and in the 6th Vol. of the *French* Encyclopedie, publiſhed in 1756; and more fully and ingeniouſly treated of by Dr. *Hamilton* in 1765: the cold attending the ſolution is a phænomenon ſimilar to that attending many other chemical ſolutions, and is in a leſs degree ſenſibly felt by every one who goes into a room newly waſhed, or ſtreet in the ſummer-time lately watered.

Upon taking the thermometer out of the river, its bulb was quickly covered with a thin cruſt of ice, which defended it ſo much from the cold ſubſiſting in the atmoſphere, that it did not ſink two degrèes in ten minutes; whereas, when it was wiped dry after immerſion in water, it ſunk above 20° in a leſs ſpace of time: this circumſtance ſhews that ice doth not tranſmit cold, and is explained by the experiments of M. *Richmann*, who hath eſtabliſhed it as a principle, that metallic ſubſtances are far more quickly affected in their dimenſions by the tranſitions from heat to cold, and the contrary, than any other bodies yet known.

Being deſirous of obſerving the effect of this extraordinary degree of cold upon various ſaline ſolutions, I haſtened to my elaboratory, where I happened to have a great many ſolutions of ſalts corked up in quart bottles; the bottles were not all full, but the ſolutions were perfectly ſaturated; the ſtate in which I found them is expreſſed in the following table.

Frozen wholly

- Alum
- Cream of tartar
- Arſenic
- Corroſ. ſublimate
- Borax
- Nitre

Frozen nearly

- Green vitriol
- Blue vitriol
- Rochelle ſalt
- Glauber's ſalt genuine
- White vitriol, a few glacial ſpicula

Wholly fluid

- Sea ſalt
- Sal gemmæ
- Sal ammoniac

Volatile alkaline ſalt
Fixt alkali per deliq.
Epſom ſalts } Lymington.
Glauber's ſalts } Lymington.

Theſe experiments agree upon the whole very well with thoſe of Profeſſor *Braunius*, related in the *Peterſburgh* Commentaries for 1763: for, though his ſaturated ſolutions of *Epſom* ſalts, and of fixt alkali, had begun to freeze in a leſs degree of cold, yet it is probable that his *Epſom* ſalts might have been different from thoſe manufactured at *Lymington*, and the ſolution of his fixt alkali not ſo well ſaturated as that which is made per deliquium.

During the ſame froſt, I endeavoured to find out the powers, by which different ſalts, when they are diſſolved in water, reſiſt congelation.

tion. With this view I diſſolved equal weights of ſalts, equally dry, in equal quantities of water, and expoſed the ſolutions, when they were arrived at the ſame degree of heat, in veſſels of equal and ſimilar figures to the ſame freezing atmoſphere; and accurately marking the times in which they began to freeze, I found them obſerving the following order: firſt alum, then Rochelle ſalt, green vitriol, ſugar refined, white vitriol, vitriolated tartar, Glauber's ſalt, mineral fixt alkali, nitre, blue vitriol, volatile alkali, ſal ammoniac, laſt of all, ſea ſalt. Theſe experiments were repeated once or twice with ſome attention; yet I would not be thought to propoſe the order in which I have arranged the ſeveral ſalts, as wholly to be relied on. It were to be wiſhed, that a ſufficient number of experiments were accurately made upon this ſubject; ſome general truths relative to metallic earths, and alkaline neutral ſalts, would probably be obtained therefrom, which, however unimportant in themſelves, might ſerve, upon ſome occaſion or other, as connecting links, to extend the chain of our ideas. By this compariſon of equal quantities of different ſalts diſſolved in equal quantities of water, we might be enabled to ſpeak with as much preciſion, concerning the powers by which they reſiſt congelation, as we do concerning thoſe by which they reſiſt putrefaction. I know not whether it may not be thought too curious a remark to obſerve, that the ocean is impregnated with that ſpecies of ſalt which reſiſts congelation with the greateſt power, and in ſuch a quantity as tends not to preſerve entire, but to accelerate the diſſolution of the numberleſs animals which are daily dying in it. *Beccher*, it hath been aſſerted, was acquainted with this property of common ſalt; but he ſeems only to ſpeak of it as a far leſs efficacious antiſeptic than ſugar; at leaſt, the honour of aſcertaining the proportion in which it acts as a ſeptic undoubtedly belongs to Sir *John Pringle*; for *Beccher*, in his *Phyſica Subterranea*, *lib.* I. *ſect.* v. *cap.* 1. where he is ſpeaking of this matter, ſays, "*Quod nimius ſalis uſus corpus putreſcere faciat, ſicut modicus a putredine præſervat.*"

To a table exhibiting the relative powers of neutral ſalts in reſiſting congelation, another might be uſefully added, denoting the powers of all the known acids and alkalis when diluted to a given denſity; as alſo of vinous ſpirits, from highly rectified ſpirits of wine to water impregnated with the minuteſt quantity of ſpirit. Not but that it may be conjectured *a priori*, that in this laſt caſe the reſiſtance to congelation would be directly as the quantity of ſpirit contained in given quantities of water. I made an experiment of this kind with ſea ſalt; in equal quantities of water were diſſolved quantities of ſea ſalt, increaſing in the arithmetical progreſſion, 0, 5, 10, 15, 20, &c.; the times in which the ſolutions began to freeze, reckoning from the time in which ſimple water began, increaſed accurately in the ſame progreſſion: hence it may be inferred, that, in ſalt of the ſame kind, the reſiſtance to congelation is in the direct ſimple proportion of the quantity of ſalt diſſolved; this concluſion cannot be extended to ſalts of different kinds, ſince water ſaturated with ſea ſalt is more difficultly congealed than when ſaturated with various other ſalts, which it diſſolves in greater quantities.

ESSAY V.

Account of an Experiment made with a Thermometer, whoſe Bulb was painted black, and expoſed to the direct Rays of the Sun.

DURING the hot weather, which we had in the latter end of June and the beginning of July, 1772, I made an experiment at *Cambridge*, which I then thought no more of, but which an accident hath brought to my mind again; and I now venture to relate an account of it, in hopes that ſome philoſophical friend will take the trouble of proſecuting it. I expoſed the bulb of an excellent thermometer to the direct rays of the ſun, when the ſky was perfectly free from clouds: the mercury roſe to 108° of *Fahrenheit*'s ſcale, and continued ſtationary. A fancy ſtruck me, to give the bulb a black covering; this was eaſily effected by a camel's hair pencil and *Indian* ink; the mercury ſunk a few degrees during the application of the coating, and the evaporation of the water; but preſently after roſe to 118°, or 10° in conſequence of the black coat with which I had covered that part of the bulb which was expoſed to the ſun. If the bulbs of ſeveral correſponding thermometers were painted of different colours, and expoſed at the ſame time to the ſun, for a given period, ſome conjectures, reſpecting the diſpoſition of the ſeveral primary colours for receiving and retaining heat, might be formed, which could not fail of being, in ſome degree, intereſting.

TRACT VI.

Plan of Chemical Lectures, 1771.

INTRODUCTION.

HISTORY of chemiſtry, and of alchemy.

Of the elements of chemiſtry commonly received—Earth, air, fire, water.

Conjectures concerning the mutual convertibility of chemical elements.

Of the ſolidity, fluidity, fixity, and volatility of bodies in different degrees of heat.

Conjectures concerning the formation and nature of the atmoſphere.

Calcination, ſublimation, evaporation, diſtillation *per aſcenſum, per retortam, per deſcenſum,* explained and exemplified.

Of the different degrees of heat required for the conducting of different operations: the terms *venter equinus, balneum maris vel mariæ, balneum vaporis, capella vacua, balneum cinerum, arenæ, limaturæ ferri,* explained.

The heat of boiling homogeneous fluids in open veſſels, ſhewn to be incapable of increaſe from an increaſe of fire.

The heat of boiling homogeneous fluids ſhewn to be greater or leſs, within certain limits, in proportion to the augmentation or diminution of the preſſure of the atmoſphere, or other elaſtic fluid upon their ſurface.

A fluid contained in a veſſel expoſed to the action of boiling water for any length of time, does not acquire the heat of boiling water without it come in immediate contact with it.

The heat of boiling oil aſcertained, and the uſe of a *balneum olei* illuſtrated.

The ſtructure and uſe of ſimple, reverberatory, melting, cupelling and other furnaces explained.

The nature of the inflammable principle, *pabulum ignis*, or phlogiſton, inquired into from the phænomena attending the combuſtion of vegetable oil, animal fat, vinous ſpirits, charcoal, and metallic ſubſtances.

The earth obtained from the combuſtion of the phlogiſton of metallic ſubſtances converted into its primary metallic appearance by the addition of phlogiſton; exemplified in the reduction of the flowers of zinc by charcoal, and of minium by charcoal, by animal fat, and by iron filings.---The identity of phlogiſton inferred from the preceding experiments.

Definition, and general diviſion of ſaline ſubſtances into acid, alkaline, and neutral ſalts.

Acid ſalts diſtinguiſhed commonly from alkaline and neutral ſalts by their taſte; by effervefcing with calcareous earths; and by changing the blue colour of ſyrup of violets, and other blue vegetable infuſions into a red.

Alkaline ſalts diſtinguiſhed from neutral ſalts by taſte; by effervefcing with acids; and by changing the blue colour of ſyrup of violets into a green.

A neutral ſalt made from a mixture of an acid and an alkali.---The term ſaturation explained.

The vegetable fixed alkali extracted from the aſhes of charcoal by ſolution and filtration; and from tartar by combuſtion---Pearl-aſh---Pot-aſh---Salt of tartar.

Salt of tartar rendered liquid by expoſure to the air, improperly in that ſtate called oil of tartar *per deliquium*.

Quantity of water attracted from the air by a given quantity of ſalt of tartar, in a given time, eſtimated by experiment.

The mineral fixed alkali extracted from the aſhes of the plant kali, jointed glaſs-wort, marſh ſamphire, or *ſalicornia* of *Linnæus*, and from ſea tangle, &c. by ſolution and filtration,

tration, and its difference from the vegetable fixed alkali ſhewn.

Volatile and fixed alkalis diſtinguiſhed from each other by the ſmell, and by the different colours produced in mixing them with a ſolution of corroſive ſublimate. --- Uncertainty of this criterion remarked.

OF MINERALS.

Of the Pyrites and green Vitriol.

Natural hiſtory of the pyrites.

Sulphureo - ferrugineous pyritæ from the chalk pits of *Cherry-hinton* analyſed by diſtillation---Sulphur---Ferrugineous reſiduum: method of aſſaying any particular ſpecies of the pyrites for ſulphur.

Analyſis of ſulphur by combuſtion --- Phlogiſton --- Volatile ſulphureous acid: method of obtaining the acid of ſulphur at *Batterſea*, and in other places.

Iron-pyritæ deſulphurated by roaſting.

Green vitriol extracted from the deſulphurated iron-pyritæ by elixation and cryſtallization: method of aſſaying any particular ſpecies of the pyrites for green vitriol.

Iron-filings, ſulphur, and water kneaded together: Intumeſcence---Incaleſcence---Incenſion of the mixture.

Conjectures concerning the origin of ſubterraneous fires and volcanos founded upon the preceding experiment.

Green vitriol extracted from the reſiduum of the preceding experiment.

Of the weathering, or ſpontaneous decompoſition and ſimultaneous vitriolization, of the pyrites.

Various ſpecies of the pyrites exhibited in a vitriolizing ſtate.

Green vitriol extracted from vitriolized pyritæ.

Account of the principal green vitriol works in *Great Britain.*

Native green vitriol---*German*---*Engliſh.*

Method of purifying green vitriol from copper, and of diſcovering whether it contains copper.

Green vitriol calcined to a white, yellow, and red colour.

Calcined green vitriol analyſed by diſtillation---vitriolic acid---ferrugineous *reſiduum* or colcothar.

Of the vitriolic Acid and its Combination with Water, with fixed, and with volatile alkaline Salts.

The vitriolic acid of the preceding proceſs concentrated, or rectified by diſtillation: Weak acid, commonly called ſpirit of vitriol---Reſiduum, ſtrong acid, improperly called oil of vitriol.

Degree of heat ariſing from the mixture of oil of vitriol and water obſerved by a thermometer: proportions producing a *maximum* of heat aſcertained by experiment.

Quantity of water attracted from the air by a given quantity of oil of vitriol, in a given time, eſtimated by experiment: uſe of oil of vitriol as an hygrometer.

Specific gravity of oil of vitriol determined.

Equal bulks of oil of vitriol and water mixed together: ſpecific gravity of the mixture not equal to the mean ſpecific gravity of the two fluids.

Dr. *Hook*'s experiment, concerning the penetration of dimenſions in the mixture of oil of vitriol and water, conſidered.

Vitriolic acid not abſorbed into the pores of water, as *Muſſchenbroek* and others have ſuppoſed.

Acid of vitriol combined with the fixed alkaline ſalt of tartar---*Tartarus vitriolatus* made after *Tachenius*'s manner---General properties of vitriolated tartar.

Sir Iſaac Newton's theory concerning chemical attraction ſtated and explained---*Geoffroy*'s, *Gellert*'s, and other tables of affinity explained.

Acid of vitriol combined with the fixed alkaline ſalt of kelp---*Glauber's ſal mirabilis*---General properties of Glauber's ſalt.

Acid of vitriol combined with volatile alkali---*Sal ammoniacus ſecretus*

cretus Glauberi; general properties of this ſalt.

Of the Combination of the vitriolic Acid with Earths.

Acid of vitriol combined with earth of *ſal catharticus amarus*---Hiſtory of *Epſom* ſalts.

Acid of vitriol combined with argillaceous earths---Alum.

Natural hiſtory of aluminous ores.

Schiſtus aluminoſus crude, and calcined, from Yorkſhire and Lancaſhire.

Account of the principal alum works in England.

Method of aſſaying aluminous mineræ.

Alum calcined---*Alumen uſtum.*

Alumen uſtum diſſolved in water and cryſtallized.

Analyſis of alum by diſtillation---Vitriolic acid---Reſiduum.

Analyſis of alum by precipitation with fixed alkaline ſalt of tartar---Vitriolated tartar---Earth of alum.

Account of the experiments of *Marggraf* and *Macquer* upon the earth of alum.

Nature of argillaceous earths---Conjectures concerning the identity of argillaceous and vitrifiable earths.

Acid of vitriol combined with vitrifiable earth.

Acid of vitriol combined with calcareous earth.

Natural hiſtory of plaſter-ſtone, alabaſter, gypſum, ſelenites.

Specimens of plaſter-ſtone from *Montmartre* near *Paris*, from *Cornwall*, *Derbyſhire*, *Weſtmoreland*, &c.

Specimens of rhomboidal ſelenites from *Shotover Hill* in *Oxfordſhire*, of ſtriated gypſum from *Derbyſhire*, of *gypſum phoſphoreſcens* from *Bononia*, &c.

Gypſeous earth analyſed by boiling it with ſalt of tartar --Vitriolated tartar and calcareous earth obtained therefrom.

Hiſtory of the diſcovery of the *Bononian phoſphorus* — Experiments therewith.

Artificial Bononian phoſphorus made from calcined oyſter ſhells and flowers of ſulphur after Mr. *Canton*'s method---Account of his experiments therewith.

Of the Combination of the vitriolic Acid with Phlogiſton, Spirits of Wine, and Oils.

Acid of vitriol combined with phlogiſton—Sulphur.

Natural hiſtory of ſulphur.

Sulphur nativum, pellucidum et *opacum*, from *Solfatara* near *Naples*.

Sulphur nativum pulverulentum aquis efloreſcens, from the baths of *Aix-la-Chapelle*.

Account of the different methods of preparing crude ſulphur in *Germany*, *Saxony*, &c.

Sulphur purified by ſublimation —Flowers of ſulphur—Sulphur flag.

Sulphur cryſtallized.

Spirit of ſulphur *per campanam*— Various ways of obtaining it.

Acid of vitriol changed into a volatile ſulphureous acid, by the addition of phlogiſton in a ſtate of diſſipation.

Volatile ſulphureous acid combined with the fixed alkaline ſalt of tartar---*Stahl*'s ſulphureous ſalt.

Sulphureous ſalt of Stahl changed

into vitriolated tartar by ſimple expoſure to the air, or by the addition of oil of vitriol.

Sulphur united with fixed alkaline ſalt by fuſion---*Hepar ſulphuris.*

Hepar ſulphuris changed into vitriolated tartar by the diſſipation of the phlogiſton---Analyſis of ſulphur.

Vitriolated tartar changed into hepar ſulphuris by the addition of phlogiſton---Syntheſis of ſulphur.

The proportion of the conſtituent parts of ſulphur deduced from the two preceding experiments of Stahl.

Hepar ſulphuris digeſted in rectified ſpirits of wine---*Tinctura ſulphuris.*

Sulphur rendered ſoluble in water, by boiling it with fixed alkaline *lixivia,* or with lime-water.

Sulphur precipitated from the preceding ſolutions by weak ſpirits of vitriol—*Lac ſulphuris—Sulphur præcipitatum.*

Sulphur united with volatile alkaline ſpirits by diſtilling it with ſal ammoniac and lime—*Tinctura ſulphuris volatilis.*

Action of water and acids upon ſulphur examined.

Remarks upon *M. le Comte de Lauragais*' Method of uniting Sulphur with Spirits of Wine.

Sulphur diſſolved in oil of turpentine·····*Balſamum ſulphuris terebinthinatum.*

Sulphur diſſolved in oil of olives·····*Balſamum ſulphuris ſimplex.*

Hiſtory of the Diſcovery of *Homberg's pyrophorus.*

Various pyrophori made from alum, Glauber's ſalt, &c. calcined in conjunction with matters containing phlogiſton.

Oil of vitriol mixed with rectified ſpirits of wine·····Phænomena attending the commixtion·····The mixture diſtilled·····Æther of *Frobenius*·····Sulphureous acid·····Oil of ſpirits of wine·····Artificial reſin·····Sulphur·····Caput mortuum.

Specific gravity of æther determined.

Cold produced by the evaporation of æther·····Of ſpirits of wine·····Of alkaline ſalts, &c.

Application of this principle of producing cold by evaporation, to the cooling of liquors, &c. in hot climates.

Phænomena attending the combuſtion of æther.

Miſcibility of æther with water, in certain proportions, proved.

The characteriſtics of æther, as difdiſtinguiſhed from ſpirits of wine, and from eſſential oils.

Oil of vitriol mixed with oil of turpentine.....Artificial reſin reſulting therefrom: Proportions of the ingredients which, cæteris paribus, produce the moſt ſolid reſin.

The preceding artificial reſin diſtilled---Sulphureous acid.....Oil.... Sulphur.....Caput mortuum.

Of Nitre.

Account of the different methods of making nitre in the Eaſt-Indies, and in Europe.

Of the medium quantity of nitre annually imported into Great Britain from the Eaſt-Indies, and exported to various parts of Europe.

Crude nitre extracted from nitrous earths.

Crude Eaſt-India nitre purified from ſea ſalt, and calcareous earth.

Nitre from America.

Account of the attempts to make nitre in England.

Analyſis of the mother water of nitre.

Hiſtory of the medicinal application of *magneſia alba.*

Nitre analyzed by diſtilling it with calcined vitriol.....Acid of nitre or *aqua fortis*.....Reſiduum.

Reſiduum of the preceding proceſs analyzed.....Vitriolated tartar..... Ferrugineous earth.

Acid of nitre procured by diſtilling nitre with ſand, clay, alum, &c.

Fuming acid of nitre procured by diſtilling nitre with oil of vitriol .....Reſiduum examined.

Fuming acid of nitre purified by difdiſtilling it with nitre. Teſt of the purity of acid of nitre.

Fuming acid of nitre mixed with water.....Change of colour obſerved .....Degree of heat aſcertained.

Fuming acid of nitre mixed with ſnow, and with powdered ice.....Degree of cold aſcertained.

Fuming acid of nitre mixed with the cryſtals of kelp.....Degree of heat obſerved.

Diluted acid of nitre mixed with cryſtals of kelp.....Degree of cold obſerved.

Fuming acid of nitre ſimple, and combined with oil of vitriol mixed with various oils.....Inflammation produced thereby.....Reſidua.

Enumeration of the various oils which have been obſerved to take fire, to effervefce without taking fire, and which neither effervefce or take fire, when mixed with the fuming acid of nitre.

Acid of nitre dulcified with rectified ſpirits of wine, by diſtillation and digeſtion.

Nitrous æther made by ſpontaneous diſtillation, and by digeſtion.

Nitre alkalized by fuſion.

Nitre alkalized by charcoal.... *Clyſſus* of nitre.

Volatile alkali in a concrete form ſeparated from the *clyſſus* of nitre.

Nitre detonated with tartar in various proportions.....White flux..... Black flux.

Nitre deflagrated with ſulphur—*Sal polychreſtus*—*Sal prunellæ*.

Pulvis fulminans made from nitre, ſalt of tartar and ſulphur.... Exploſion of pulvis fulminans.

Hiſtory of the invention of gunpowder.

Gunpowder made from nitre, ſulphur, and charcoal---Account of the different proportions of the ingredients uſed in different countries, and in different works in England ---Beſt proportions aſcertained.

Method of extracting nitre from damaged gunpowder at Woolwich, &c.

Gunpowder decompoſed----The three conſtituent parts exhibited ſeparate---Method of detecting frauds uſed in the compoſition of gunpowder explained.

Acid of nitre combined with calcareous earth---Calcareous nitre---*Phoſphorus Balduini.*

Acid of nitre combined with argillaceous earth---Aluminous nitre.

Acid of nitre combined with the vegetable fixed alkali---Regenerated nitre.

Acid of nitre combined with the mineral fixed alkali---Quadrangular or cubic nitre.

Acid of nitre combined with volatile alkali---Nitrous ſal ammoniac.

Of the uſe of nitre in agriculture.

The uſe of ſnow in fertilizing the ground, ſhewn not to depend upon the nitre it is generally ſuppoſed to contain.

Of Sea Salt.

Natural hiſtory of ſea ſalt---*Sal marinus, fontanus, foſſilis.*

Hiſtory of the diſcovery of foſſil ſalt in England.

Account of the method of preparing ſea ſalt in different parts of the world.

Of the different antiſeptic powers

of ſea ſalt according to the different proceſſes by which it is prepared.

Of the bittern of ſea ſalt.

Of the method by which Epſom ſalts, common Glauber's ſalts, and magneſia, are extracted from the bittern of ſea ſalt at Lymington, and other places.

Method of diſtinguiſhing the genuine ſal mirabilis Glauberi from the counterfeit of the ſhops.

Analyſis of ſea water, attempted.

Comte *Marſigli*'s artificial ſea water.

M. de Francheville's opinion, concerning the ſaltneſs of the ſea, examined.

Mr. *Boyle*'s opinion, concerning the uniform ſaltneſs of the ſea at different depths, examined.

Account of various attempts to edulcorate ſea water.

Of Mr. *Irving*'s late attempt.

Of the teſts of the purity of diſtilled ſea water.

Of the phoſphoric quality of ſea water in particular places, and at particular times in the ſame place.

Mr. *Canton*'s experiments concerning the cauſe of the luminouſneſs of ſea water.

Account of other opinions concerning the ſame ſubject.

Sea ſalt diſſolved and cryſtallized.

Decrepitation and fuſion of ſea ſalt.

Sea ſalt analyzed by diſtilling it with acid of vitriol after Glauber's manner --- Fuming ſpirit of ſalt --- Reſiduum.

The reſiduum of the preceding proceſs analyzed, and the fixed alkaline baſis of ſea ſalt obtained therefrom after Marggraf's method.

Glauber's fuming ſpirit of ſalt purified by diſtilling it with ſea ſalt.

Sea ſalt diſtilled with vitriol, clay, &c.---Acid of ſea ſalt---Reſidua.

Acid of ſea ſalt ſeparated from its alkaline baſis by acid of nitre.

Acid of ſea ſalt combined with calcareous earth---*Phoſphorus Hombergi.*

Acid of ſea ſalt combined with argillaceous earth---Muriatic alum.

Acid of ſea ſalt combined with earth of *ſal catharticus amarus.*

Acid of ſea ſalt combined with fixed alkali of tartar---*Sal febrifugus Sylvii.*

Acid of ſea ſalt combined with alkali of kelp---Sea ſalt regenerated.

Acid of ſea ſalt combined with volatile alkali---Artificial ſal ammoniac.

Acid of ſea ſalt dulcified by diſtillation with ſpirits of wine.

Marine æther made after the *Marquis de Courtanvaux*'s manner.

Aqua regia made by mixing together acid of ſea ſalt and acid of nitre.

Aqua regia made by diſſolving ſea ſalt or ſal ammoniac in acid of nitre ---Its difference from the preceding aqua regia, remarked.

Of ſea ſalt as a condiment, and as a manure.

Of Sal Ammoniac.

Natural hiſtory of ſal ammoniac.

Method of making ſal ammoniac in *Egypt*.

Method of making ſal ammoniac in *Europe*.

Sal ammoniacus glebоſus from Solfaterra.

Sal ammoniac purified by ſublimation.

Sal ammoniac purified by cryſtallization.

Sal ammoniac diſſolved in ſpirits of wine.

Sal ammoniac deflagrated with nitre.

Sal ammoniac analyſed by diſtilling it with the acid of vitriol, and of nitre---Marine acid---Reſidua.

Sal ammoniac analyſed by diſtilling it with fixed alkali---Volatile alkali---Reſiduum.

The volatile alkaline ſpirit of ſal ammoniac procured by diſtilling it with quicklime---Cauſtic ſpirit of ſal ammoniac.

The reſiduum of the proceſs examined---*Oleum calcis.*

Volatile alkaline ſalt ſpirit procured by diſtilling ſal ammoniac with chalk---Mild ſpirit.

Cauſtic ſpirit of ſal ammoniac mixed with acids, with ſpirits of wine, lime-water, calcareous nitre, &c.

Mild ſpirit of ſal ammoniac mixed with acids, with ſpirits of wine, lime-water, calcareous nitre, &c.

Eau de luce made.

Degree of cold, produced during the ſolution of ſal ammoniac in water, obſerved by a thermometer.

Equal quantities of water of different temperatures ſaturated with ſal ammoniac, and the degrees of cold ſeverally produced during the ſaturation, remarked.

Of the greateſt poſſible degree of cold which can be produced in water by the ſolution of ſal ammoniac.

Of the uſe of ſal ammoniac in various arts.

Of Borax.

Natural hiſtory of *tincal*, or crude borax.

Borax vitrified.

Glaſs of borax diſſolved in water, and cryſtallized.

Sal ſedativus Hombergi ſeparated from borax by the acids of vitriol, nitre, ſea ſalt, and vinegar, and procured by ſublimation and cryſtallization.

The reſidua examined, and the mineral fixed alkali ſeparated therefrom.

Borax regenerated by combining together ſal ſedative and mineral alkali.

Sal ſedative diſſolved in ſpirits of

wine, the green colour of the flame obſerved.

Of copper ſuppoſed to be contained in borax.

Account of the attempts to make artificial borax in *England.*

Of the mechanic uſes of borax.

Of Mineral Earths, crude and calcined.

Diſtillation of ſiliceous, calcareous, argillaceous, and gypſeous earths.

Account of the experiments lately made at *Paris* by M. *Darcet*, and others, concerning the infuſibility and volatility of diamonds in a great degree of heat.

Vitrification of a mixture of earths, ſeparately unvitrifiable in a given degree of heat.

Glaſs made from a mixture of alkaline ſalts and powdered flints.

Hiſtory of the invention of glaſs.

Of the method of making and poliſhing plate glaſs in France, &c.

Siliceous earths rendered ſoluble in water by means of alkalis---*Liquor ſilicum.*

Of European and Aſiatic porcelain, and their ſpecific difference.

Account of the methods of making the white and yellow Staffordſhire ware.

Calcareous earths converted into lime by calcination.

Calcareous earths converted into lime by ſolution and precipitation.

Lime converted into calcareous earth.

Dr. *Black*'s theory of lime explained.

The quantity of fixed air contained in alkalis, and calcareous earths, and ſeparable by ſolution, eſtimated by the Honourable *Hen. Cavendiſh.*

The loſs of weight ſuſtained by calcareous earths during calcination eſtimated by experiment, and ſhewn to correſpond with the quantity of fixed air, ſeparated therefrom by ſolution.

Of the ſolubility of lime in water.

Of the pellicle of lime-water, and of the exceſs of its weight above the weight of the lime diſſolved.

Is the ſmalleſt quantity of lime wholly ſoluble in the largeſt quantity of water, without undergoing a freſh calcination?

Of marle.

Of the uſe of lime, marle, &c. in agriculture.

Of Arſenic.

Natural hiſtory of white pyrites,

orpiment,

orpiment, realgar, cobalt ores, and other mineral ſubſtances affording arſenic.

Method of procuring arſenic in *Saxony*, called from its powdery appearance, *farina arſenicalis.*

Farina arſenicalis purified, and changed into white cryſtalline arſenic, by being mixed with pot-aſh and ſublimed.

Farina arſenicalis mixed with the ſulphur of ſulphureous pyrites, and changed into yellow or red cryſtalline arſenic by ſublimation.

Arſenic diſſolved in oil of olives, in oil of turpentine, in a ſolution of fixed alkali, in rectified ſpirits of wine, in aqua fortis, in acid of ſea ſalt, in aqua regia, in oil of vitriol, in vinegar, and in water.

Arſenic and nitre diſtilled together---Acid of nitre---Reſiduum.

Macquer's neutral arſenical ſalt extracted from the reſiduum.

Nitre and arſenic fuſed together in open veſſels---Fume---Reſiduum called nitre fixed by arſenic.

Arſenic combined with phlogiſton, and ſublimed into a metallic appearance, commonly called *regulus* of arſenic.

OF METALLIC SUBSTANCES IN GENERAL.

Of Mercury in a fluid State.

Natural hiſtory of mercury and of cinnabar.

Mercury extracted from earths or ſtones with which it is mixed, by ſimple lotion, and by diſtillation without addition.

Mercury extracted from minerals,

in which it is mineralized, by diſtillation with addition.

Method of aſſaying mercurial minerals, and of diſcovering whether any particular mineral contains mercury.

Methods of purifying mercury.

Mercury changed into a black powder by long continued trituration.

Mercury changed into a red powder by calcination---*Mercurius calcinatus*---*Mercurius præcipitatus per ſe.*

Mercury boiled with water.

Mercury revivified, from the powders obtained by trituration, and calcination, by ſimple diſtillation.

Account of *Boerhaave*'s experiments relative to the unchangeableneſs of mercury, by the proceſſes of digeſtion, and diſtillation.

Account of Profeſſor *Braunius*'s experiments, relative to the converſion of mercury into a ſolid malleable metal, at *Peterſburgh*, by an artificial cold reſulting from the ſolution of ſnow in the fuming ſpirit of nitre.

Of the degree of heat of boiling mercury, and of the limits within which mercury may be uſed as a thermometer.

Mercury triturated with turpentine, with lard, with ſugar, &c.---Mercurial plaſters, ointments, pills.

Mercury diſſolved in acid of nitre---The ſolution diluted with diſtilled water, *aqua mercurialis*.

The ſolution of mercury in acid of nitre cryſtallized.

The ſame inſpiſſated---*Calx mercurii*.

The inſpiſſated maſs, or cryſtallized ſalt, calcined to a red colour---*Mercurius præcipitatus ruber.*

Mercurius præcipitatus ruber dulcified by ſpirit of wine---*Mercurius corallinus---Arcanum corallinum.*

Mercury precipitated from its ſolution in acid of nitre by copper.

Mercury corroded into a ſaline maſs by oil of vitriol.

The preceding ſaline maſs partly diſſolved, principally changed into an inſipid, indiſſoluble, yellow powder, by frequent ablution in warm water---*Mercurius emeticus flavus---Mercurii præcipitatum flavum---Turpethum minerale.*

Mercury precipitated, from the waſhings of turpeth mineral, by alkalis.

Waſhings of turpeth mineral inſpiſſated, and deliquiated---*Oleum mercurii.*

Mercury united by ſublimation with the acid of ſea ſalt; corroſive ſublimate made from a mixture of unwaſhed turpeth mineral and ſea ſalt.

Corroſive ſublimate made from cryſtals of mercury in the nitrous acid and ſea ſalt.

Corroſive ſublimate made from crude mercury, nitre, calcined vitriol, and ſea ſalt.

Corroſive ſublimate rendered mild and inſipid, by trituration with a ſufficient quantity of crude mercury and ſubſequent ſublimations---*Mercurius dulcis ſublimatus---Calomelas---Aquila alba---Panacæa mercurialis---Draco mitigatus*, &c.

Specific gravities of corroſive ſublimate and calomel, determined.

Corroſive ſublimate diſſolved in water, and cryſtallized.

Corroſive ſublimate diſſolved in ſpirits of wine.

Mercury precipitated from a ſolution of corroſive ſublimate in water by fixed alkalis---*Mercurius præcipitatus fuſcus*, by volatile alkali---*Mercurius præcipitatus dulcis*, by lime water---*Aqua phagedenica.*

Mercury precipitated from its ſolution in acid of nitre by the acid of ſea ſalt, or by any neutral ſalt containing the acid of ſea ſalt---*Mercurius præcipitatus albus.*

Mercury precipitated from its ſolution in acid of nitre by the acid of vitriol, or any neutral ſalt containing the acid of vitriol---Turpeth mineral.

Mercury diſſolved in the vegetable acids, native, and fermented, and in fixed, and volatile alkalis, after *Marggraf*'s method.

Account of *M. le Comte de la Garaye*'s tincture of mercury in ſpirits of wine.

Mercury united with ſulphur by trituration, and by fuſion---*Æthiops* mineral.

A mixture of ſulphur and mercury ſublimed---Factitious cinnabar.

Factitious cinnabar levigated---*Vermillion*.

Method of diſcovering whether vermillion be adulterated with red lead.

Mercury revivified by diſtilling cinnabar with iron-filings.

Mercury united with volatile tincture of ſulphur, and with hepar ſulphuris.

OF SEMIMETALS.

Of Antimony, and Regulus of Antimony.

Natural hiſtory of antimony, and other ores of *regulus* of antimony.

Crude antimony ſeparated from earthy and ſtony impurities by eliquation, or diſtillation per deſcenſum —*Morſuli reſtaurantes Kunckelii.*

Crude antimony digeſted with aqua regia, ſolution of the metallic, and ſeparation of the ſulphureous part effected thereby.

Crude antimony calcined to an aſh-coloured calx.

Calcined antimony vitrified.

Glaſs of antimony digeſted with aqua regia, ſulphur ſometimes ſeparated thereby --- Differences obſervable in the fuſibility, colour, pellucidity, and ſolubility of glaſs of antimony in wines, and other menſtruums, according to the different degrees of calcination uſed in preparing it.

Regulus of antimony prepared, by fuſing the calx, or glaſs of antimony with charcoal, ſoap, or other phlogiſtic matters.

Regulus of antimony prepared, by fuſing crude antimony with iron, with lead, with copper, &c.

Regulus of antimony prepared, by fuſing crude antimony with tartar and nitre.

Chief mechanic uſes of regulus of antimony noticed.

Regulus of antimony volatilized by a ſtrong fire---Flowers of regulus of antimony.

Method of reducing flowers of regulus of antimony.

Action of acids upon regulus of antimony, examined.

Regulus of antimony combined with the marine acid by diſtilling antimony and corroſive ſublimate together---*Cauſticum antimoniale*, or butter of antimony.

Regulus of antimony precipitated from the marine acid, by diluting butter of antimony with water---*Pulvis algaroth*---*Mercurius vitæ.*

Regulus of antimony precipitated from the water uſed in the preceding proceſs, commonly called *ſpiritus vitrioli philoſophicus* by an alkali.

Bezoard mineral prepared, by repeated abſtractions of the acid of nitre from butter of antimony---*Spiritus bezoardicus.*

Antimony and nitre mixed together in the proportion of 2 to 1, and deflagrated---*Crocus antimonii mitior.*

Antimony and nitre mixed together in equal parts, and deflagrated---*Crocus antimonii*---*Hepar antimonii,* edulcorated---*Crocus metallorum.*

Antimony and nitre mixed together in the proportion of 1 to 2, deflagrated and edulcorated---*Emeticum mite antimonii.*

Antimony and nitre mixed together in the proportion of 1 to 3, deflagrated and edulcorated---*Calx antimonii*---*Antimonium diaphoreticum dulce.*

Different chemical properties of the preceding, and other ſimilar combinations of nitre and antimony, explained; general account of their medical powers deduced therefrom.

Waſhings of diaphoretic antimony conſidered --- *Materia perlata*, or *Boerhaave's ſulphur fixatum ſtibii* precipitated therefrom.

Regulus of antimony reduced to calx, ſimilar to diaphoretic antimony, by deflagration with nitre, called *ceruſſe of antimony.*

Antimony combined with fixed alkali by boiling them together------*Kermes* mineral ſpontaneouſly precipitated from the ſolution.

Tinctura antimonii made by digeſting hepar antimonii in ſpirits of wine.

Vinum antimoniale ſive emeticum, made by digeſting crocus antimonii, or glaſs of antimony in mountain wine.

Tartarus emeticus made by boiling glaſs, or crocus of antimony with cream of tartar.

Tartarus emeticus made, after *Macquer*'s manner, by combining pulvis algaroth and cream of tartar.

Of the medical virtues of antimonial preparations in general, and the cauſe of the variable and uncertain effects of particular preparations explained.

Of Zaffre and Regulus of Cobalt.

Method of making *zaffre* in Saxony.

The zaffre of the ſhops diſſolved in all the mineral acids.

The difference of the colour of

the ſolution of zaffre in weak and ſtrong acid of ſea ſalt obſerved.

The *tawny* colour of zaffre diſſolved in weak ſpirit of ſalt, changed into a *green* by heating the ſolution.

Zaffre changed into a blue glaſs by vitrification, called *ſmalt.*

Method of preparing from the blue glaſs of zaffre, an impalpable powder, called in that ſtate *azure, enamel blue, powder blue.*

Of *lapis lazuli,* and the pigment called *ultramarine blue* prepared therefrom, and its difference from the azure prepared from zaffre.

Regulus of cobalt procured from zaffre or ſmalts, when melted in conjunction with matters containing phlogiſton.

General properties of regulus of cobalt enumerated.

Account of the manufacturing of ſmalts in England.

Orpiment and quicklime digeſted together with water---*Liquor vini probatorius.*

Uſe of the preceding liquor in detecting adulterations of wine by *ſaccharum Saturni,* ſhewn from the different colours of the precipitates attending its mixture with genuine and adulterated wine.

Experiments with the aforeſaid liquor as a ſympathetic ink.

Of Nickel.

Nickel not ſoluble in acid of vitriol, with difficulty in acid of ſea ſalt, readily by acid of nitre into a green colour.

Nickel precipitated from acid of nitre by a fixed alkali into a greeniſh powder.

Nickel compared with regulus of cobalt.

Experiments with ſympathetic inks from ſolutions of nickel and cobalt.

Of Biſmuth.

Natural hiſtory of biſmuth.

Biſmuth ſublimed into yellowiſh flowers by a ſtrong fire.

Biſmuth changed into an aſh-coloured powder by calcination.

Calx of Biſmuth vitrified.

Vitrified calx of biſmuth reduced by the addition of phlogiſton.

Biſmuth diſſolved in acid of nitre.

Solution of biſmuth in acid of nitre cryſtallized.

Biſmuth precipitated from the ſolution in acid of nitre by the affuſion of water --- *Magiſtery of biſmuth* --- *Blanc de fard.*

Biſmuth precipitated from the

waſhings of the magiſtery by a fixed alkali.

Biſmuth and mercury melted together---Amalgam.

Biſmuth, lead, and mercury, melted together---Method of falſifying quickſilver---Method of detecting the adulteration of quickſilver.

Biſmuth not miſcible by fuſion with nickel.

Of Zinc.

Natural hiſtory of *lapis calaminaris*, *black jack*, and other ores of zinc.

Zinc procured by diſtilling lapis calaminaris with charcoal.

Account of the method of making Engliſh zinc at the copper works near Briſtol, and its difference from Indian zinc ſhewn.

Zinc calcined in a gentle fire, inflamed in a ſtrong fire---Flowers of zinc, or *lana philoſophorum* ſeparated during the combuſtion of zinc.

Flowers of zinc vitrified.

Flowers of zinc reduced in cloſe veſſels.

Flowers of zinc diſſolved in all the acids.

Zinc deflagrated with nitre.

Zinc diſſolved in acid of vitriol ---Nature of the black *flocculi* ſeparated during the ſolution.

Solution of zinc in acid of vitriol cryſtallized---white vitriol.

Method of diſcovering whether white vitriol contains copper.

Difference between Engliſh and *Goſlarian* white vitriol.

Zinc diſſolved in acid of nitre.

Solution of zinc in acid of nitre cryſtallized.

Zinc diſſolved in the concentrated acid of ſea ſalt, and in the aqueous acid of vitriol---Inflammable air ſeparated during the ſolution in each menſtruum.

The quantity, and ſpecific gravity of the inflammable air ſeparated from zinc by ſolution, eſtimated by the Hon. *Henry Cavendiſh.*

Zinc not acted upon by ſulphur, or liver of ſulphur---Purified thereby from all other metallic ſubſtances.

Zinc not miſcible by fuſion with biſmuth.

OF METALS.

Of Lead.

Natural hiſtory of lead ores.

Account of the two different methods of extracting lead from its ore, as practiſed in Derbyſhire.

Lead extracted from its ore---Method of aſſaying ſimple lead ores.

Lead in fuſion partly volatilized,

chiefly converted into a gray calx, called *plumbum uſtum*, or calcined lead.

Plumbum uſtum melted in a ſtrong fire---*Litharge*.

Account of the method of making red lead from plumbum uſtum, as practiſed in Derbyſhire.

Account of the method of making red lead from litharge, as practiſed in Flintſhire.

Remarks concerning the quantity, and cauſe of the increaſe of weight, gained by the converſion of lead into minium.

Glaſſes of lead made from minium ſimple, and mixed with vitrifiable earth in different proportions.

Artificial ores, perfectly reſembling ſome kinds of natural ores of lead, made from an union of lead and ſulphur.

Of *black lead* or *wadd.*

Method of diſtinguiſhing the factitious from the true black lead.

Black lead expoſed to a ſtrong fire in cloſe veſſels---Fixity remarked.

Black lead expoſed to a ſtrong fire in open veſſels---Loſs of weight remarked.

Calcined black lead attracted by the magnet.

Lead corroded into a white calx by the vapour of vinegar, called *ceruſſe*, or white lead.

Account of the method of manufacturing white lead at Holywell, and other places, and of the increaſe of weight gained by the lead.

White lead, minium, or litharge, diſſolved in diſtilled vinegar, and cryſtallized---*Sugar of lead.*

Crude lead, white lead, minium,

or litharge diſſolved in oil of olives ---Common *diachylon* plaſter.

Method of diſcovering whether oil of olives be adulterated, by means of lead, with rapeſeed, or other expreſſed oils.

Lead ſeparated, from its ſolution in oils, by vinegar.

Lead diſſolved in acid of nitre, and cryſtallized.

Lead precipitated from acid of nitre by acid of vitriol, or any neutral ſalt containing acid of vitriol; by acid of ſea ſalt, or any neutral ſalt containing acid of ſea ſalt.

Lead diſtilled to dryneſs with oil of vitriol---Sulphureous acid---Sulphur---Saline reſiduum.

Sulphur procured inſtantaneouſly by pouring oil of vitriol upon lead in fuſion, and collecting the vapour.

Lead or minium diſtilled with ſal

ammoniac---Volatile alkaline ſpirit ---Volatile alkaline ſalt---Reſiduum, or a combination of the acid of ſea ſalt with lead, called *plumbum corneum.*

Plumbum corneum fuſed.

Plumbum corneum diſſolved in water, and cryſtallized.

Lead and mercury melted together in different proportions—Amalgams of various conſiſtencies.

Of Copper.

Natural hiſtory of copper.

Account of the proceſſes uſed in extracting copper from its ore, at Ecton, Macclesfield, Cheadle, &c.

Regulus and *ſcoria* of the firſt, ſecond, third, and fourth fuſion of copper ore examined, and the reaſon of their differences explained.

Copper combined with ſulphur by ſtratification and cementation---*Æs uſtum.*

Copper combined with ſulphur by fuſion---Artificial ore of copper.

Copper combined with arſenic by fuſion---*White copper.*

Of Chineſe white copper, improperly called *tutenag*, and its difference from the preceding white copper ſhewn.

Copper changed into *braſs*, by cementing and fuſing copper in conjunction with calcined calamine and charcoal.

Copper changed into braſs, by ſubſtituting, in the preceding proceſs, calcined black jack for calamine.

Braſs changed into copper, by diſſipating the zinc or metallic part of the calamine, in a ſtrong fire.

The increaſe of weight, gained by the copper in being changed into braſs, eſtimated.

Copper melted with zinc---*Pinchbeck.*

Difference between pinchbeck and braſs obſerved, and the reaſon explained.

Copper melted with tin in various proportions --- *Bell metal* --- *Bronze,* &c.

Equal parts of copper and tin melted together; their mutual penetration and increaſe of ſpecific gravity obſerved.

Copper diſſolved in oil of vitriol.

Solution of copper in oil of vitriol cryſtallized---*Blue vitriol.*

Copper precipitated from a ſolution of blue vitriol by iron---*Cuprum præcipitatum,* called *ziment copper.*

Account of the cement or ziment

waters at Newſol in Hungary, Arklow in Ireland, in Angleſea, &c. and of the methods of procuring copper from them.

Copper diſſolved in acid of nitre, and cryſtallized.

Copper precipitated from acid of nitre by chalk---*Verditer blue.*

Copper diſſolved in acid of ſea ſalt, and cryſtallized.

Cryſtals of copper, in the acids of ſea ſalt, and nitre, when diſſolved in ſpirits of wine, communicate a green colour to the flame.

Copper diſſolved in oils, in vegetable acids, in fixed, and volatile alkalis, in neutral ſalts, &c.

Account of the method of making *verdigriſe* at Montpellier, and in England.

Various mechanical applications of verdigriſe enumerated.

Verdigriſe diſſolved, in part, in diſtilled vinegar.

Solution of verdigriſe in diſtilled vinegar cryſtallized, improperly called *viride æris diſtillatum.*

Cryſtals of verdigriſe diſtilled---Concentrated acid of vinegar, called *acetum radicatum*---Cupreous reſiduum.

Acetum radicatum mixed with rectified ſpirits of wine, and acetous æther made after the manner of *M. le Comte de Lauragais.*

Of Iron.

Natural hiſtory of iron.

Account of the proceſſes uſed in extracting iron from its ores in different parts of England and Wales; and of the attempts to make pig iron by coke and charred peat.

Method of converting pig iron into bar iron.

Of the tenacity of iron wire.

Iron converted into ſteel.

Steel converted into iron.

Steel hardened, and rendered brittle and elaſtic.

Of tempering of ſteel.

Iron deprived of its phlogiſton by various ways---Different kinds of *crocus Martis*.

Natural hiſtory of *ochres*.

Red and yellow ochres converted into iron by the addition of phlogiſton.

Iron deprived of its phlogiſton by deflagration with nitre.

Iron combined with ſulphur.

Iron diſſolved in acid of vitriol---*Sal Martis*.

Iron diſſolved in acid of ſea ſalt.

The inflammable air ariſing from

iron during the two preceding ſolutions collected and inflamed.

Of fulminating damps in mines.

Method of freeing the coal-pits at Whitehaven from inflammable air deſcribed.

Iron diſſolved in acid of nitre, elaſtic but not an inflammable air produced thereby.

Hiſtory of the diſcovery of the method of making *Pruſſian blue.*

Pruſſian blue made by precipitating a ſolution of green vitriol with an alkali ſaturated with phlogiſton.

The colouring matter of Pruſſian blue extracted by an alkali.

Iron precipitated from any of its acid ſolvents into a blue powder by a fixed alkali, ſaturated with the colouring matter of Pruſſian blue.

Iron precipitated from any of its acid ſolvents into a black powder by a decoction of galls or other aſtringent vegetables.

Nature of ink and of the black dye, and the difference between them explained.

Beccher's experimentum ferriferum conſidered.

Iron ſhewn to exiſt in common ſand, in coloured clays, in the aſhes of vegetables, in the aſhes obtained from the blood, urine, and fleſh of animals.

Vegetable aſhes melted into a green or blue glaſs, according to the violence of the fire.

Iron filings or colcothar of vitriol mixed with ſal ammoniac and ſublimed—*Flores martiales*—Reſiduum.

Reſiduum deliquiated—*Lixivium Martis*—*Oleum ferri.*

Flowers of iron digeſted with ſpirits of wine—*Tinctura florum martialium.*

Iron precipitated from its ſolution in acid of nitre by fixed alkali—*Stahl*'s alkaline tincture of iron.

Iron combined with cream of tartar by grinding them together—*Rotuli martiales—Mars ſolubilis*; by boiling, *tartarus chalybeatus, tinctura ſtyptica Helvetii.*

Iron diſſolved in Rheniſh wine—*Vinum chalybeatum.*

Of Tin.

Natural hiſtory of tin.

Of the proceſſes of ſtamping, buddling, and trunking uſed in *Cornwall* for preparing tin ore for fuſion.

Of the *magnetiren* uſed in ſome parts of Germany.

Tin melted and granulated.

Tin rendered hard and ſonorous

by being melted in conjunction with regulus of antimony, with zinc, with biſmuth, &c.

Of *pewter* and its different kinds.

Of different metallic mixtures which melting with leſs heat than the metals to which they are applied, conſtitute ſolders of various kinds.

Method of manufacturing *tin plates* in England and Germany, and of tinning copper veſſels.

Tin calcined ſingly and in conjunction with lead—*Putty*.

Calces of lead and tin melted with calcined flints, or other vitrifiable earths, and alkaline ſalts, in various proportions—*white enamels*.

White enamels converted into different colours, by the addition of metallic calces, and applied upon Engliſh and Indian porcelain.

Paſtes and artificial precious ſtones

made, and their difference from coloured enamels explained.

Tin amalgamated with quickſilver, and the amalgam mixed with ſulphur and ſal ammoniac, and ſublimed—Reſiduum called *aurum moſaicum or muſicum.*

Tin diſſolved in aqua regia—Different conſiſtences of the ſolutions.

Tin diſſolved in acid of nitre.

Uſe of the preceding ſolutions of tin in precipitating the colouring matter of cochineal.

Woollen and linen boiled in cochineal precipitated by tin—Reaſon of the different dyes explained by *Macquer.*

Inflammable air ſeparated from tin during its ſolution in acid of vitriol and acid of ſea ſalt.

Account of *Marggraf*'s experiments upon the ſolubility of tin in vegetable acids, native and fermented.

Tin amalgamated with quickſilver, and the amalgam diſtilled with corroſive ſublimate—*Liquor fumans Libavii*—Butter of tin—Revivified mercury.

Looking glaſs ſilvered by amalgamating mercury and tin.

Tin, biſmuth, and lead melted together, and mixed with mercury—Method of ſilvering concave glaſs veſſels with the mixture.

Of Silver.

Natural hiſtory of ſilver.

Account of the method of ſeparating native ſilver from the ſtones or earths in which it is imbedded, by amalgamation with mercury; as practiſed at *Potoſi* and other Spaniſh ſilver mines in America, and at *Kungſburg* in Norway.

Account of the method of ſeparating ſilver when mineralized with ſulphurated lead, as practiſed in Flintſhire, and in Northumberland.

Cardiganſhire lead ores aſſayed for ſilver.

Silver purified from ſemimetals, and imperfect metals, by cupellation with lead.

Silver purified from ſuch minute portions of copper as eſcape cupellation, by fuſion with nitre and borax.

Silver ſeparated from $\frac{1}{3}$, or any leſs part of its weight of gold by ſolution in acid of nitre—Quartation or departure.

Silver recovered from its ſolution in acid of nitre by precipitation with copper.

Solution of ſilver in acid of nitre cryſtallized.

Cryſtals of ſilver melted—*Lunar cauſtic.*

Silver precipitated from acid of nitre, by acid of vitriol, or by any neutral ſalt containing acid of vitriol.

Silver diſtilled to dryneſs with acid of vitriol—Sulphureous acid—Saline reſiduum.

Saline reſiduum diſſolved in water, and cryſtallized.

Silver precipitated from acid of nitre, by acid of ſea ſalt, or by any neutral ſalt containing it—*Luna cornea.*

Marggraf's method of obtaining ſilver abſolutely pure by the reduction of luna cornea.

Silver precipitated from its ſolution in acid of nitre by fixed alkali.

Precipitated ſilver diſſolved in vegetable acids, in volatile, and phlogiſticated fixed alkalis, according to *Marggraf*'s method.

Pure ſilver made harder by being melted with copper in the proportion of 37 to 3—*Standard ſilver of England.*

Silver precipitated from acid of nitre, largely diluted with water, by means of mercury—*Arbor Dianæ.*

Silver combined with ſulphur into an artificial ore reſembling the *minera argenti vitrea.*

Of Gold.

Natural hiſtory of gold.

Method of ſeparating native gold from ſands, earths, &c. by amalgamation with quickſilver.

Method of extracting gold when mineralized, or when ſo mixed with ſulphur by means of other metals as to eſcape the action of quickſilver and aqua regia.

Gold ſoluble in aqua regia, but not in acid of nitre.

Silver ſoluble in acid of nitre, but not in aqua regia.

Method of purifying gold from all metallic ſubſtances by ſolution in aqua regia, and precipitation with green vitriol.

Method of ſeparating a minute portion of gold from a large quantity of ſilver, by melting the mixture with ſulphur, as practiſed at Rammelſberg.

Gold precipitated from its ſolution in aqua regia made with acid of nitre and acid of ſea ſalt, by volatile alkali—*Aurum fulminans.*

Aurum fulminans deprived of its fulminative power by oil of vitriol, by fuſion with ſulphur, by fixed alkali, and in part by ablution with water.

Gold precipitated from its ſolution in aqua regia, when largely diluted with water, by plates of tin, or by a ſolution of tin in the ſame menſtruum — *Purple magiſtery of Caſſius.*

Glaſs changed into an artificial ruby by being melted with Caſſius' purple magiſtery.

Gold extracted from its ſolution in aqua regia, and kept ſuſpended in æther.

Method of ſeparating gold from gilt copper.

Gold precipitated from its ſolution in aqua regia by fixed alkali.

Precipitated gold diſſolved by the ſame menſtruums as precipitated ſilver.

Gold diſtilled to dryneſs with the acid of vitriol, with the acid of ſea ſalt, and with the acid of nitre—Inſoluble in theſe menſtruums.

Gold diſſolved in hepar ſulphuris.

Pure gold hardened by being melted with copper, or with an admixture of copper and ſilver, in the proportion of 22 to 2—*Standard gold of England.*

Gold amalgamated with mercury—Methods of gilding and ſeparating gold from gilt works.

OF MINERAL WATERS IN GENERAL, AND THEIR VARIOUS IMPREGNATIONS.

Different methods of aſſaying mineral waters, and their imperfections.

Of *thermæ*, or hot mineral waters,

and the different conjectures concerning the cauſe of the heat.

Account of Dr. *Brownrigg*'s experiments on the fixed air contained in *Spa* water.

M. *Lane*'s experiments concerning the ſuſpenſion of iron in water, by means of fixed air diſcharged either from fermenting, or efferveſcing mixtures.

Of Bituminous Subſtances.

Natural hiſtory of bituminous ſubſtances.

Newcaſtle coal diſtilled—Phlegm—Acid—Air—Oil—Caput mortuum.

Air diſcharged from Newcaſtle coal by diſtillation, collected, and ſhewn to be inflammable, and to retain its elaſticity and inflammability for ſeveral days.

Peat from the iſle of *Ely* diſtilled —Phlegm—Acid—Oil—Alkali—Caput mortuum.

Amber diſſolved in ſpirits of wine.

Amber precipitated from its ſolution in ſpirits of wine by water.

Amber diſtilled—Phlegm—Acid ſpirit—Volatile acid ſalt—Oil—Caput mortuum.

Method of rectifying oil of amber.

Method of purifying ſalt of amber.

Amber varniſh made by different methods.

OF VEGETABLES.

Of vegetable juices ſpontaneouſly extravaſated, or exuding upon inciſion.

Of liquid Reſins or Balſams.

Venice turpentine diſtilled without addition with the heat of boiling water—Acidulated phlegm—Colourleſs eſſential oil, commonly called æthereal ſpirit of turpentine—*Reſinous reſiduum.*

The reſiduum of the preceding proceſs diſtilled with a degree of heat exceeding that of boiling water—Acid—Yellow oil—Reſiduum called *colophony.*

Colophony diſtilled to dryneſs—Acid—Reddiſh oil, called by ſome, balſam of turpentine—Caput mortuum.

Common turpentine diſtilled with water—Eſſential oil, vulgarly called ſpirit of turpentine—Reſiduum—*Terebinthina cocta*, or common roſin.

Turpentine diſſolved in ſpirits of wine, and precipitated therefrom by water.

Of *tar* and *pitch*, and the method of procuring them.

Tar diſſolved in part in water.

Of lamp black, and the method of obtaining it.

Balſam of *capivi* diſtilled *balneo arenæ*—Acid—Yellow oil—Blue or green oil—Caput mortuum.

Of balſam of *Gilead*, balſam of *Peru*, balſam of *Tolu*, liquid amber, &c.

Of ſolid Reſins.

Benzoine diſſolved in ſpirits of wine, and precipitated therefrom by water—Virgin's milk.

Acid phlegm and eſſential ſalt, commonly called flowers of benzoine, obtained from benzoine by ſublimation.

Eſſential ſalt obtained from benzoine by elixation with water and cryſtallization.

Flowers of benzoine diſſolved in water, and in ſpirits of wine.

The reſiduum from the ſublimation of the flowers of benzoine diſtilled—Acid—Oil of different conſiſtences—Caput mortuum.

Elemi — Maſtic — Copal — Dragon's blood, and other ſolid reſins diſſolved in ſpirits of wine and oils.

Different kinds of varniſhes made, and applied upon wood and metals.

Of Camphor.

Native camphor.

Rough camphor refined by ſublimation.

Rough camphor refined by ſolution in ſpirits of wine.

Camphorated ſpirits of wine inflamed.

Camphor diſſolved in acid of nitre, and in acid of vitriol.

Camphor ſeparated from ſpirits of wine, and from mineral acids by the addition of water.

Of Gums.

Gum arabic, gum tragacanth, gums from pear trees, plùm trees, apricot trees, &c. diſſolved in water—Mucilages.

Gums diſſolved in water, and precipitated therefrom by ſpirits of wine.

Gums diſtinguiſhed from reſins principally by their ſolubility in water, and inſolubility in ſpirits of wine, and by their being neither fuſible, nor inflammable in fire.

Gum arabic diſtilled—Acid—Oil—Volatile alkali—Caput mortuum.

Of Gummy Reſins.

Gum *ammoniac* diſſolved in ſpirits of wine.

Gum ammoniac diſſolved in water.

Of *aſſa fœtida*, myrrh, frankincenſe, and other gummy reſins.

OF VEGETABLE JUICES OBTAINED BY TRITURATION, AND EXPRESSION.

Of eſſential Salts of Plants.

Native aqueous juices expreſſed and clarified.

Native aqueous juices evaporated and cryſtallized—Eſſential ſalts.

Of neutral ſalts contained in vegetables.

Hiſtory of ſugar, and of the method of preparing it.

Brown or gray Muſcovade—Melaſſes, or treacle.

Method of refining ſugar.

Sugar diſſolved in water and cryſtallized—*Saccharum candum, et cryſtallinum.*

Sugar diſſolved in rectified ſpirits of wine, and cryſtallized.

Refined ſugar diſtilled — Acid — Oil—Air—Caput mortuum.

Of ſaccharine juices obtainable from maple trees, birch trees, ſycamore trees, &c. by tapping; from fruits and roots of various kinds, by ſolution in ſpirits of wine; from the ſpontaneous exudations of the *fraxinus rotundiore folio*, and other trees producing *manna*; and from various flowers affording honey to the bee.

Native juices of vegetables inſpiſſated to different conſiſtences— Liquid or ſolid extracts by expreſſion.

Of *aloes*, *opium*, *acacia vera*, and other ſolid extracts by expreſſion.

Of expreſſed Oils.

Oils obtained by expreſſion from

linſeed, muſtard ſeed, ripe olives, almonds, walnuts, &c.

Expreſſed oils diſtinguiſhed principally from eſſential oils, in not being ſoluble in ſpirits of wine, nor volatile in the heat of boiling water, and in having ſcarce either taſte or ſmell.

Method of impregnating expreſſed oils with the odorous principle of violets, lilies, roſes, &c.---Various perfumes.

Oil of olives diſtilled ---Phlegmatic acid---Oil—Fixed oil---Caput mortuum.

Of the rancidity of expreſſed oils.

Expreſſed oils ſuſpended in water by means of mucilages---Emulſions ---Milky juices of plants.

Of the combination of oils with fixed alkali.

Fixed alkali deprived of its fixed

air by quicklime—Cauſtic alkali—Soap lees.

Soap lees inſpiſſated—*Cauterium potentiale, lapis infernalis.*

Oil of olives, oil of turpentine, train oil, tallow, &c. diſſolved in ſoap lees—Soaps of various kinds.

Solution of ſoap in diſtilled water, and in ſpirits of wine.

METHOD OF ANALYZING VEGETABLES FURTHER EXPLAINED, BY INFUSION, AND DECOCTION IN VARIOUS MENSTRUUMS.

Carduus benedictus infuſed in cold water.

Carduus benedictus boiled in water.

Peruvian bark infuſed in cold water.

Peruvian bark boiled in water.

Jalap digeſted with ſpirits of wine —Tincture of jalap—Reſiduum.

The reſiduum of the preceding proceſs boiled with water and inſpiſſated—Aqueous extract of jalap.

Reſin of jalap precipitated from tincture of jalap by water.

Method of obtaining the reſinous and gummy parts of vegetables, and of making ſpirituous, aqueous, and mixt extracts.

Aqueous decoction of red ſaunders.

Spirituous decoction of red ſaunders.

Aqueous decoction of Brazil wood.

Spirituous decoction of Brazil wood.

Aqueous decoction of alkanet root.

Spirituous decoction of alkanet root.

Red ſaunders digeſted in oil of turpentine.

Alkanet root digeſted in oil of turpentine.

Archel boiled in water, in oils, in acids, in ſpirits of wine, in fixed alkalis, and in volatile alkalis.

The colouring matter of ſome vegetables precipitated by alum, ſolutions of tin, &c.—*Lakes.*

Various experiments relative to the production, change, and recovery of colours, by different ſaline additions to coloured vegetable infuſions.

Of dying in general.

METHOD OF ANALYZING VEGETABLES BY DISTILLATION, EXEMPLIFIED IN VARIOUS INSTANCES, AND VARIOUS DEGREES OF HEAT.

Mint, thyme, roſemary, lavender, or other aromatic plants diſtilled with a heat *leſs* than that of boiling water and *without* addition—*Spiritus rector*, or odorous principle.

The ſame plants diſtilled *with* the addition of water, and with the *heat* of boiling water—Eſſential oils—Aromatic or ſimple diſtilled waters.

Of the different weights, colours, and conſiſtences, of eſſential oils.

Eſſential oils by expreſſion from oranges, citrons, &c.

Method of obtaining them in Italy.

Eſſential oils ſoluble in ſpirits of wine.

Roſemary tops, lavender flowers, &c. diſtilled with ſpirits of wine—Spirit of roſemary, ſpirit of lavender, &c. more commonly called Hungary water, lavender water, &c.

Eſſential oil of roſemary, and of lavender, precipitated from Hungary water and lavender water, by the affuſion of water.

Of diſtilled ſpirituous waters.

Roſemary, &c. after the extraction of their eſſential oil, diſtilled to dryneſs — Phlegm — Acid — Empyreumatic oil — Caput mortuum.

Method of making charcoal explained.

Charcoal not acted upon by water, acids, alkalis, vinous ſpirits, or oils.

Charcoal decompoſed by burning — Phlogiſton — Reſiduum.

Quantity of reſiduum from a given weight of charcoal eſtimated.

Fixed alkaline ſalt and earth obtained from the reſiduum.

Of the method of manufacturing and depurating pot-aſh.

Of the difference between the mineral fixed alkali, or *natron* of the ancients, and the vegetable fixed alkali.

Analyſis of Woods.

Oak diſtilled *balneo Mariæ* — Phlegm—Reſiduum.

Reſiduum diſtilled — Phlegm — Acid air—Oil lighter and heavier than the acid—Caput mortuum.

Air from oak not deſtructive of flame, but inflammable after paſſing through water, and through fixed alkaline lixivia, and retaining its inflammability for ſeveral days.

Of the different quantities of charcoal, of liquid contents, and of fixed air obtained from equal weights of oak, box, hazel, willow, and other woods by diſtillation.

Of the beſt kinds of charcoal requiſite for the making of gunpowder, fluxing of metals, &c.

Volatile alkali diſengaged from the acid of oak by fixed alkali.

Acid of box-wood rectified.

Rectified acid of box ſaturated with vegetable and mineral fixed alkalis — Nature of neutral ſalts from the diſtilled acids of vegetables.

Analyſis of the *Tetradynamia* of Linnæus.

Muſtard ſeed, pepper wort, &c. diſtilled with the heat of boiling water—Phlegm ſapid and odorous, but neither manifeſtly acid nor alkaline.

Muſtard ſeed, &c. diſtilled with a degree of heat ſuperior to that of boiling water—Volatile alkali, acid, air, oil, caput mortuum.

Of Soot.

Wood ſoot diſtilled—Acid—Volatile alkali — Empyreumatic oil —

Sal ammoniac — Caput mortuum, yielding fixed alkali.

Of Wax.

Wax diſtilled — Acid — Oil — Congealed oil—Caput mortuum.

Congealed oil or butter of wax, rectified — Acid — Yellow oil — Fat brown reſiduum.

Methods of bleaching yellow wax, and of colouring bleached wax.

OF FERMENTATION IN GENERAL.

Of the vinous Fermentation.

Hiſtory and uſe of *malting* as preparatory to the fermentation of farinaceous ſeeds.

Equal weights of barley, rye, wheat, oats, beans, peas, converted into malt, and after decoction for the ſame time in equal quantities of water expoſed to fermentation—*Ale* of different ſorts.

The medium heat of fermenting wort eſtimated by the thermometer, and ſhewn to be equal to the medium heat of an animal body.

The air generated during the vinous fermentation ſhewn to be deleterious to animal life and to flame.

The ſpecific gravity of air, generated by vinous fermentation proved by the Hon. *Henry Cavendiſh* to be greater than that of common air, and to be equal to that ſeparable from marble by ſolution, or about 511 times lighter than water, when common air is ſuppoſed 800 times lighter.

Equal weights of raiſins, refined ſugar, brown ſugar, treacle mixed with equal quantities of water and fermented—*Wines* of different kinds.

Ale diſtilled—Malt ſpirits—-reſiduum.

Wine diſtilled--Brandy--Reſiduum.

Potatoes fermented and diſtilled—*Potatoe brandy.*

Of the methods of making malt ſpirits, brandies, rums, arracks, and the origin of their different odours and flavours explained.

Malt ſpirits, brandy, &c. diſtilled —*Alcohol*, or rectified ſpirits of wine —Acidulated phlegm.

Of the identity of alcohol from whatever fermented liquor it is diſtilled.

Of *proof ſpirit.*

Uſual methods of eſtimating the ſtrength of brandies, rums, &c. and their imperfections.

Alcohol and water mixed together, the bulk of the mixture ſhewn to be conſiderably *leſs* than the ſum of the ſeparate bulks.

Method of judging accurately concerning the ſtrength of ſpirituous liquors pointed out.

Of the arrack or *coſmos* prepared by the *Calmuck Tartars* from mare's milk.

Method of obtaining white and red *tartar*.

Tartar purified—Cream or cryſtals of tartar.

Tartar diſtilled—Acid—Air—Oil —Volatile alkali—Caput mortuum.

Fixed alkaline ſalt extracted from the caput mortuum of diſtilled tartar without burning it.

Cryſtals of tartar combined with abſorbent earths.

Cryſtals of tartar combined with the fixed alkali of tartar—*Sal vegetabilis, tartarus tartariſatus.*

Cryſtals of tartar combined with the fixed alkali—*Sal polychreſtus de Saignette—Rochelle ſalt.*

Cryſtals of tartar combined with volatile alkali.

OF THE ACETOUS FERMENTATION, OR THE SPONTANEOUS CONVERSION OF ALES AND WINES INTO ALEGARS AND VINEGARS.

Method of making vinegars, and of diſcovering whether they are adulterated with oil of vitriol.

Vinegar diſtilled—Phlegm—Acid —Extract.

Method of diſcovering whether vinegar be depraved by lead.

Extract of vinegar diſtilled—Acid —Empyreumatic oil—Volatile alkaline ſalt, and ſpirit—Caput mortuum.

Vinegar concentrated by *freezing* the phlegmatic part.

Diſtilled vinegar combined with abſorbent earth.

Diſtilled vinegar combined with the fixed alkali of tartar—*Sal Diureticus*—*Terra foliata tartari.*

Diſtilled vinegar combined with the mineral fixed alkali, and cryſtallized.

Diſtilled vinegar combined with volatile alkali—*Spiritus mindereri*—Acetous ſal ammoniac.

Combinations of the acid of tartar with the vegetable and fixed alkalis, decompoſed by the acid of vinegar.

Difference between the acid of tartar and that of vinegar.

Of the putrefactive fermentation of vegetables.

OF ANIMALS.

General analyſis of animal fluids exemplified in the analyſis of milk, blood, urine, and whites of eggs.

Of Milk.

Cows milk diſtilled *balneo mariæ* —Phlegm tranſparent, colourleſs, inſipid—Unctuous ſaline reſiduum.

Aſſes milk diſtilled balneo mariæ —Phlegm—Reſiduum,

Proportion of phlegm ſeparable from equal weights of cows milk and aſſes milk by diſtillation B. M. aſcertained.

Equal weights of cows milk, goats milk, woman's milk, aſſes milk, evaporated to dryneſs—Proportion of the reſiduums, and of the ſaline and earthy matter contained in them.

Reſiduum from the diſtillation of milk B. M. diſtilled---Acid---Empyreumatic oil---Volatile alkali—Caput mortuum, containing fixed alkali.

Milk ſpontaneouſly ſeparated into cream and ſkim-milk.

Cream reſolved into butter—Curd—Whey.

Skim-milk reſolved into whey—Curd—Butter.

Butter diſtilled—Acid—Oil—Caput mortuum.

Curd diſtilled—Alkali volatile in a fluid and concrete form·····Fetid oil—Caput mortuum.

Whey evaporated and cryſtallized—*Sugar of milk*—*Sea ſalt.*

Milk not coagulable by the heat of boiling water.

Milk coagulable by acids, by alkalis, by vinous ſpirits, by ſome neutral ſalts earthy and metallic.

Of Blood.

Blood examined by a microſcope —Tranſparent fluid—Red globules of various ſizes.

Blood warm from the vein diſtilled balneo mariæ—colourleſs, inſipid phlegm—Reſiduum.

Of the quantity of phlegm contained in the blood of different animals, and ſeparable therefrom by the heat of boiling water.

Phlegm, impregnated with volatile alkali, obtained from blood by the heat of a boiling fixed alkaline lixivium.

Blood exſiccated by the heat of the ſun.

Blood exſiccated by the heat of the ſun, or by diſtillation B. M. not ſubject to putrefaction.

Exſiccated blood diſtilled—Volatile alkaline ſpirit and ſalt—Air—Empyreumatic oil — Caput mortuum.

Blood ſpontaneouſly reſolved, by expoſure to the air, into a fluid and coagulated part---*Serum*---*Craſſamentum*.

Account of Mr. *Hewſon*'s experiments, relative to the cauſe of the ſpontaneous coagulation of blood when taken out of an animal body.

Blood prevented from ſpontaneous coagulation by ſea ſalt, and other neutral ſalts.

The *craſſamentum* reſolved, by ablution, into a white fibrous part, called by ſome the coagulable lymph, not ſoluble in water, and a red colouring part, called the red globules, reckoned ſoluble in water.

The fibrous part or coagulable lymph diſtilled.

The red globular part diſtilled.

The ſerum coagulated by boiling water, by acids and by vinous ſpirits.

Of Urine.

Freſh Urine gives no marks of containing either acid or alkaline ſalts.

Freſh human urine diſtilled B. M. —Colourleſs phlegm with an urinous ſmell—Reſiduum.

Reſiduum diſtilled—Volatile alkali in a fluid and concrete form—Oil—Sal ammoniac—Caput mortuum, yielding ſea ſalt by elixation, and fixed alkali by calcination.

Horſes urine diſtilled—phlegm—Volatile alkaline ſpirit—Oil—Caput mortuum, yielding fixed alkali without calcination, and ſea ſalt by elixation.

Human urine evaporated and cryſtallized—Fuſible, eſſential, native, microcoſmic, phoſphoric ſalt of urine—Sal ammoniac—Sea ſalt.

Horſes urine, evaporated to a due conſiſtency, does not yield a fuſible ſalt, but a portion of ſea ſalt and a magma incapable of cryſtallization.

Earth from the exſiccation of human urine rendered white by calcination — Its habitude to fire and menſtruums examined.

Account of Marggraf's experiments on the fuſible ſalt of urine.

Volatile alkali ſeparated from

freſh urine by fixed alkali and by lime.

Of Eggs.

Whites of eggs coagulated nearly by the ſame degree of heat which coagulates the ſerum of blood.

Whites of eggs coagulable by acids and by ſpirits of wine—their uſe in clarification.

Whites of eggs diſtilled B. M. phlegm---Reſiduum.

Reſiduum diſtilled---Volatile alkali concrete and fluid---Empyreumatic oil---Caput mortuum.

Oil expreſſed from the yolks of eggs.

Of the eſſential oil, volatile acid, and expreſſed oil of ants.

Of Coral, &c.

Volatile alkali procured from coral and ſpunges by diſtillation.

Of Brains and Spermaceti.

Contents of a human cranium diſtilled—Phlegm—Volatile alkali—Fetid oil—Caput mortuum.

Of Fat.

Suet diſtilled—Acid—Congealed oil—Caput mortuum.

Of Bones and Horns.

Horns rendered ſoft and flexible by boiling in water.

Ox horn, tortoiſe ſhell, &c. diſſolved in acid of nitre.

Bones ſoftened, and in part diſſolved, by digeſtion in acids.

Earth of bones precipitated from acids by alkalis.

Gelatinous and ſaline part extracted from hartſhorn by boiling in water—Method of making glue—Portable ſoup—Iſinglaſs—Size, &c.

Inert earth remaining after the extraction of gelly of hartſhorn—*Cornu cervi philoſophice calcinatum.*

Hartſhorn diſtilled — phlegm — Volatile alkaline ſalt and ſpirit— Air — Empyreumatic oil — Caput mortuum.

Method of preparing volatile alkaline ſalt and ſpirit from bullocks bones, &c.

Animal oil diſſolved in ſpirits of wine.

Animal oil rectified,—*Oleum animale Dippelii.*

Hiſtory of Putrefaction.

Cauſtic volatile alkali rendered

mild by the air diſcharged from putreſcent bodies.

Volatile alkali ſeparated with the heat of boiling water from putrid blood, pigeons dung, and putrid urine.

Hiſtory of *Kunckel*'s phoſphorus.

Phoſphorus made by diſtilling the extract of urine with *plumbum corneum* and charcoal, according to Marggraf's method.

Phoſphorus made by diſtilling fuſible ſalt of urine and charcoal together.

Method of rectifying phoſphorus.

Several experiments with phoſphorus.

Of other vegetables which yield a phoſphorus by diſtillation.

Analyſis of the *fæces alvinæ*.

TRACT VII.

Inſtitutiones Metallurgicæ.

PRÆFATIO.

MIRUM profecto et incredibile dictu eſt, quam late per univerſas Europæ regiones ſeſe dilataverit Philoſophia Naturalis, ex quo Peripateticorum atque Ariſtotelis Auctoritatem fregerit Baconus. Hinc æque ſingulorum, ac Societatum et Academiarum Laboribus Commentariiſque, adeo jam diffuſa eſt undique et diſſeminata, ut ingentes ejus Auctus et Progreſſus Cogitatione vix quiſquam poterit complecti.

Jacebat interea *Chemia* parcius et infrequentius culta, ſanis pleriſque ſuſpecta, et, Alchemicorum propter deliramenta, ab ipſa Legum noſtrarum auctoritate improbata. At ut aliis rebus humanis ita etiam et Artium ſcientiis accidit, quæ nec in imo gradu neque in faſtigio moram patiuntur.

Chemiam, quam haud ita pridem fuiſſe audivimus domi ſqualidam, fuligine infuſcatam, et præ hominum ei deditorum pauperie pene ridiculam, foris per trivia miſere vagantem, inhianti paſſim popello præſtigias ſuas venditantem, a nemine fere non conculcatam et deſpectui habitam, noſtris tandem temporibus ſeſe alacrius erigentem, focillatam demum a Principibus, et a Philoſophis ubique excultam auſpicato ſatis admiramur. Eò quidem jam perducta eſt, ut quæ inter præcipuas plane doctrinas reponatur omnino digna ſit, cum nec in Principiorum perſpicuitate nec in Concluſionum pondere, ſive philoſophicos ſeu civiles reſpicias uſus, ulli ſcientiarum cedat.

Chemia genere *duplex* eſt; corpora vel *reſolvit* vel *componit*. Reſolutio corporum iiſdem, quibus ipſa eorum varietas ſpecifica, terminis definitur; ſingulorum abſoluta eſſe habetur cum ad *Elementa* vel principia homogenea, ſive plura ſint ſive pauciora, perducatur.

catur.—Compoſitio corporum, Geometriæ inſtar, eſt infinita.

Partium Animalium figuram, nexum, et motum Anatomici; Vegetabilium fabricam Botanici; Foſſilium ſitus atque habitus externos Mineralogici; non formas rerum ſed mixtiones Chemici, perſcrutantur.

Actiones Medicamentorum in corpora animalium tractat *Therapeutice*. Chemia autem quippe quæ reſolvat mixta, reſoluta conjungat, et varia quæ inde exoriantur phænomena dignoſcat Therapeutices ſit quaſi anima: at cum infinitas ſimul aliorum corporum naturas retegat, et actiones mutuas inveſtiget, ad univerſam potius Phyſicen, quam ad ſolam medicinam, tanquam ad ſuum ac proprium finem refertur.

Mechanica tum Phyſices tum Chemiæ ſanioris fundamenta feliciter poſuit *Newtonus*; cum de mutuis corporum Attractionibus, vel, ut Chemici loquuntur Affinitatibus, ex quibus omnis eorum Reſolutio et Compoſitio pendet, in quæſtionibus quibuſdam ſuo de re optica libello adjectis quam ſagaciſſime diſceptavit: fundamento jam poſito molem extruxere paululum Recentiores, felici admodum ſolertia; nec Ædificio Adminiculum nec forma deeſt: Faſtigium Operi quod infinitum eſt, nulla ingeniorum ſagacitas, nulla temporum diuturnitas unquam imponet.

In *Theoreticam* et *Practicam* commode dividi poteſt Chemia: hæc quæ Encheireſes docet, Opificum eſt; illa quæ veritatem exquirit, Philoſophorum. Veritatis indagatio omnis eſt Philoſophiæ finis, hæc autem veritas inter phyſicos cognitione rerum experimentis eruenda continetur. Chemia quoque infinitam propemodum experimentorum, cum multis ante ſeculis tum noſtra etiam ætate inſtitutorum, copiam complectitur, atque iiſdem univerſa nititur.

Notiora tanquam ignota proferre, depeculari aliena, antiqua undique corraſa tanquam nova ac propria venditare, hominis eſt otio abutentis: At ſimulata a ſinceris diſtinguere, dubia ſecernere a certis, indigeſtis nexum quendam conciliare et ordinem, obſcuriora illuminare, infinitis modum ſtatuere, arduum ſane ſed nec inutile nec inhoneſtum eſt. Quod ſi magno cum diſcentium commodo, in aliis philoſophiæ naturalis partibus abſolutum hocce vidimus, quid obſtat quo minus in Chemia quoque induſtriæ aliquid periclitemur? Hac mente Provinciam mihi ab Alma Matre demandatam, *Regis Ornatiſſimi* munificentia inſignitam ſimul ac ditatam, quantum in me fuerit colui, et colam.

Lectores nihil hic reperient præter *Corporum Metallicorum Affectiones* cum alienis tum meis quibuſdam experimentis enucleatas; quas in ſeriem Propoſitionum, brevem quidem at Lectionibus publicis explicandam et illuſtrandam redegi.

Opuſculum hoc Tyronum gratia, currente calamo conſcriptum, utcunque imperfectum et provectiorum notitia indignum, iis qui Chemiam a limine tantum ſalutant, vix erit inutile. Et cum nollem id extra Academiæ pomœrium evagari aut publici fieri juris, erroris ſi quid aut incuria fuderit, aut ab ipſius operis obſcuritate et difficultate irrepſerit, id ſolita pro ſua humanitate condonent oro, qui hic loci Chemiæ operam navarunt: iiſque mei adverſum ipſos ſtudii, pietatis erga Academiam hoc qualecunque Teſtimonium, omni cum cultu et obſervantia, dico atque dedico.

CAP. I.

Definitiones.

1 CORPORA quæ ponderis decrementum in igne fortiſſimo non patiuntur *Fixa* vocantur, quæ patiuntur *Volatilia*; idque magis aut minus prout majori aut minori negotio partes eorum igne diſſipantur.

2 *Partes volatiles* corporis, quæ fluidæ ſunt et ignis vi in auras agantur, *evaporari* dicuntur; cum in vaſe clauſo ſtillatim condenſentur, *diſtillari*; *Solidæ* vero, cum ſurſum evectæ in forma ſolida condenſentur, *ſublimari* dicuntur: atque hæ vel *Sublimata* vel *Flores* vocantur, prout maſſam compactam, vel pulverem friabilem efficiunt.

3 Fluidum quodvis, ſolido affuſum et ab eo diſtillatione ſeparatum, dicitur ab eo *abſtrahi*.

4 Cum partes aquoſæ fluidi cujuſvis compoſiti ab eo ſeparantur, ſive diſtillatione, ſive corporum aquam vel phlegma

abſorbentium interventu, ſive conglaciatione, fluidum remanens *dephlegmari* vel *concentrari* dicitur.

5 Corpora, quæ vel culinari vel ſolari igne, ſive ipſa ignis vi, ſive aqua poſtea affundenda (ut fit in lapidibus calcareis) in Pulverem *fragilem*, *friabilem*, terræ ſimilem fatiſcunt, *calcinari* dicuntur: Pulvis iſte *Calx* appellatur; præſertim ſi corpora ſint ex regno minerali deſumpta. Corpora quoque, cùm in hujuſmodi Pulverem Acidis corroſa dejiciantur, nonnunquam dici ſolent *in Calcem redigi*.

6 Corpora *via humida diſſolvi* dicuntur, cum partes eorum fluido cuivis ita adjunguntur, ut unum quaſi cum eo corpus viſu homogeneum conſtituant, in eo ſuſpenſæ maneant, nec tamen id opacum vel turbidum reddunt.

7 Corpora ſicca, quæ aeri expoſita fiunt fluida, *deliqueſcere* vel *Deliquium pati* dicuntur.

8 Fluidum, quo corpora diſſolvuntur, *Solvens* aut *Menſtruum* vocatur.

9 Menſtruum, cum de corpore ſolvendo nihil amplius in ſe recipere et ſuſtinere poteſt, *ſaturari* dicitur.

10 Separatio corporis a menſtruo quo ſolutum eſt, ſive ſpontanea ſit ſive coacta, et ſive ſurſum ſive deorſum fiat, *Præcipitatio humida* dicitur; atque Materia ad imum dejecta, vel ad ſummum evecta, *Magiſterium* vel *Præcipitatum* vocatur.

11 Cum partes corporis ſolidi adeo a ſe invicem vi ignis expandente ſeparantur ut fiant fluidæ, corpus *fuſum* vel *liquatum* eſſe dicitur.

12 Corpora heterogenea, quæ igne fuſa, diverſa particularum gravitate in duas partes interea ſeparantur, *Præcipitationem ſiccam* vel *fuſoriam* ſubire dicuntur. Pars illa quæ gravitate ſua majori imum petit, *Regulus*, altera huic ſuper incumbens *Scoria* appellatur.

13 *Eliquatio* eſt cum eo ignis gradu in quo altera Mineræ compoſitæ pars ſolida ſeu refractaria manet, altera fluit et ab illa ſeparetur.

C A P. II.

De Subſtantiis metallicis in genere.

1 SUbſtantiæ metallicæ, arte metallurgica e mineris, eductæ et fuſione purgatæ, ſunt corpora omnium

longè ponderoſiſſima et (niſi ſubtilius partes dividantur) opaciſſima, aqua non ſolubilia, igne fuſilia, at calore atmoſphæræ terreſtris (Mercurio excepto), non fluida, fulgore et nitore peculiari inſignia. Hæ in duas claſſes, alteram Metallorum, alteram Semi-metallorum diſtribui ſolent.

2 Metalla, quæ hactenus cognita ſunt, ſex vulgo numerantur; Aurum, Argentum, Plumbum, Cuprum, Ferrum, et Stannum.

3 Semi-metalla habentur Platina (quæ metallis potius annumerari debeat), argentum vivum, Regulus Antimonii, Biſmuthum, Zincum, Regulus Cobalti, et Nickel. Ad hæc ab omnibus fere, at temere forſan, adjungitur Regulus Arſenici.

4 Metalla a Semi-metallis majori ſua malleabilitate præcipue diſtinguuntur.

5 Metalla fere dividuntur in duos ordines, metalla perfecta ſeu nobilia, et metalla imperfecta ſeu ignobilia. *Perfecta* habentur Aurum et Argentum; quibus adjungi debet Platina. Reliqua *imperfecta* eſſe deprehenduntur.

6 *Metalla perfecta* ſunt, quæ in igne violentiſſimo et fixa manent, et calci-

nationem nullam patiuntur: *imperfecta*, quæ in igne et calcinationem patiuntur et partium diſſipationem.

7 Omnes ſubſtantiæ metallicæ, exceptis forſan Auro, Platina, Argento et Argento vivo, ſi in igne aperto comburantur in calces convertuntur, quæ difficilius aut facilius vitrificationem admittunt prout calcinationem magis minuſve perfectam ſubierint.

8 Calces et vitra metallica, cum Carbone, Oleo, Sevo, aliiſve ſubſtantiis Phlogiſton debito ſtatu in ſe continentibus, præſertim in vaſe clauſo, igni expoſita in formam ſuam priſtinam metallicam reducuntur, modo calcinationem nimiam non perpeſſæ ſunt; ipſa operatio vocatur *Reductio*.—Annon omnes Subſtantiæ Metallicæ conſtant ex terra vitreſcente et ſubſtantia inflammabili? Quod ſi Phlogiſton ſit uniforme quiddam ſibi ubicunque reperiatur ſimile, quæri poteſt 1^{mo} num terræ metallicæ ab aliis omnibus terris vitreſcentibus genere diſcrepant: et proinde, num Arte Chemica ſubſtantiæ Metallicæ generari queant: 2^{o} utrum ſubſtantiarum Metallicarum dif-

ferentia oriatur a ſpecifica quadam terrarum differentia; an a diverſa proportione et nexu quibus eadem terra cum Phlogiſto conjungitur; an ab interpoſitione aliorum quorundam corporum: et proinde poſſint necne in ſe invicem tranſmutari?

9 Subſtantiæ Metallicæ, fuſione inter ſe miſtæ, raro magnitudinem illam habent quæ oriri debeat a magnitudinibus partium componentium ſimul ſumptis. In quibuſdam vero, ut in mixtura Stanni ex Cupri decrementum magnitudinis et incrementum gravitatis ſpecificæ ſunt admodum notabilia. In aliis, ut cum Stannum et Zincum una colliquantur, tantum eſt magnitudinis incrementum, ut gravitas ſpecifica ſive denſitas mixturæ minor ſit gravitate ſpecifica corporis levioris. In mixtura Cupri et Biſmuthi ea fere deprehenditur denſitas quæ ſecundum regulas communes hydroſtaticas expectari debeat.

10 Quædam ſubſtantiæ Metallicæ, Ex. Gr. Aurum, Argentum, Cuprum, Plumbum, Stannum et Zincum, igne fuſæ adeo magnitudine augeri, et ſpecifica gravitate diminui dicuntur, ut

fruſtulum ſolidum ejuſdem materiæ, cuilibet earundem cum fluidæ ſint injectum, ſubmergatur et in fundum ſubſidat; ut fit in Sevo, Cera et Reſinis liquefactis: Aliæ, ut Biſmuthum Antimonium et præcipuè Ferrum, adeo diminui dicuntur magnitudine, ut ſolidum fruſtulum iis innatet, quemadmodum ſulphur ſolidum ſulphuri liquato aut Glacies aquæ innatat.

11 Plurimæ, fortaſſe omnes, Subſtantiæ Metallicæ igne ſatis fuſæ et lentius poſtea frigefactæ, partium quandam regularem diſpoſitionem vel *Cryſtalliſationem* in ſuperficie viſibilem, ſed in diverſis generibus diverſam, acquirere dicuntur.

12 Omnes Subſtantiæ Metallicæ calore dilatantur, frigore contrahuntur. Hæc magnitudinis mutatio, Pyrometro menſurata, minor eſſe obſervatur in Regulo Antimonii, et major in Zinco, quam in alia quavis Subſtantia Metallica.

13 Omnes Subſtantiæ Metallicæ citius et caleſcunt et refrigeſcunt quam aut Spiritus vini, aut Olea, aut alia ulla corpora: et hinc Thermometris

et Pyrometris conficiendis adprimè aptæ ſunt.

14 Subſtantiæ Metallicæ, nec in directa nec in reciproca ratione denſitatis, cohærentiæ, duritiei, nec in ratione quavis ex his quocunque modo compoſita, nec denique ſecundum ullam generalem legem huc uſque repertam, calorem vel acquirunt vel amittunt.

15 Corpora Metallica fuſa omne cum ſalibus et terris etiam metallicis reſpuunt connubium, ſuperficiem convexam habent; præterquam quod ſi fuſa ſint in vaſis metallicis ab horum lateribus partes contiguæ atrahuntur quaſi, et ſuperficiei convexitas deſtruitur. Si cum ſulphure liquifiant, omnia (præter Aurum et Zincum) in mineras, iis quæ e fodinis eruuntur ſimiles, et ab iis vix diſtinguendas, convertuntur: cum Arſenico, omnia per fuſionem uniuntur, et ab eo fragilia redduntur.

16 Metalla quædam, uti Ferrum, Cuprum et Argentum, quæ ignem ut fluant fortiſſimum poſtulant, ſulphure addito citò liqueſcunt: dum alia quædam,

dam, uti Plumbum et Stannum, per ſe ſatis fuſilia, cum Sulphure conjuncta fiunt admodum refractaria.

C A P. III.

De Argento vivo ſive Mercurio.

1 MERCURIUS eſt corpus metallicum tactu frigidum, omnium (Auro et Platina exceptis) ponderoſiſſimum; eo propemodum caloris gradu quo aqua ebullit aut etiam minori, volatile; corpora, niſi metallica, non madefaciens; Atmoſphæræ terreſtris calore fluidum.

2 Mercurius frigore artificiali, a miſtura ſpiritus nitri fumantis cum nive orto, in ſolidum mutari poteſt.

3 Mercurius frigore in ſolidum conſtrictus eſt metallum eximio nitore ſplendens; mallei patiens; duritie et ſono quem reddit plumbo perſimile.

4 Magnitudo Mercurii frigore fixi minor eſſe dicitur parte circiter 10ª quam magnitudo ejuſdem Mercurii ad ebullitionem calefacti.

5 Mercurius, cum jamjam ſit vel in calore ebulliturus, vel in frigore fluiditatem ſuam amiſſurus, celeriter aſcendere et deſcendere obſervatur.

6 Mercurius purgatiſſimus, diu multumque agitatus, converti poteſt aliqua ex parte, forſan omnis, in pollinem nigerrimum ſaporis acris, metallici æneì, qui igne valido, nullâ re additâ, diſtillatus fit *Mercurius vivus* vel *currens.*

7 Mercurius, in igne mitiori vaſe clauſo diutius detentus, in pollinem nigrum antecedenti ſimilem mutatur: in igne fortiori digeſtus quaſi calcinatur in pulverem primo cineraceum, deinde flaveſcentem, tandem rubrum; qui impropriè vocatur, *Mercurius præcipitatus per ſe.*

8 Mercurius calcinatus vel præcipitatus per ſe, ipſo Mercurio ponderoſior eſt et in igne fixior. Adaucto nihilominus calore diſſipatur; remanente perparva quantitate pulveris fuſci, qui vitro uſtorio in vitrum fuſcum mutatur: dum mercurius qui calcinationem non paſſus eſt, ab eo calore, nullo reſtante reſiduo, in auras pellitur.

9 Mercurius quingenties amplius diſtillatus, ſingulis vicibus ſemper quiddam pulveris rubri in retorta reliquit; at aliam non ſubiit mutationem.

10 Mercurius præcipitatus per ſe, in igne culinari, nullo addito Phlogiſto, maxima ex parte reviviſcit. Reſiduum igne fortiſſimo fixum eſt: fuſum cum Borace, in maſſam friabilem vitreſcentem vertitur; cum Plumbo cupellatum, prorſus evaneſcit.

11 Acidum Nitri mercurium facile diſſolvit. Solutio evaporata, præbet Cryſtallos albas, acerrimas, longas, nonnunquam et tenues nitro ſimiles: inſpiſſata, in maſſam vertitur albam, ſalinam, admodùm cauſticam, quæ æque ac cryſtalli igni in patella expoſita fit pulvis, primo albus, deinde flavus, tandem dum calidus manet purpureus, ſed frigeſcens ruberrimus; qui vocatur *Mercurius præcipitatus ruber*.

12 Acidum Vitrioli Mercurium vix diſſolvit, niſi ſit ebulliens et concentratum. Si diſtilletur, odorem ſulphureum a Mercurio acquirit, et Mercurius ſimul corroſus fit maſſa ſalina,

alba, quæ in igne violentiori colorem non mutat, aere non deliqueſcit, et aquam calidam affundendo partim in ea diſſolvitur, partim mutatur in pulverem flavedinis eximiæ, qui ſervida aqua ſæpius ablutus fit inſipidus; et vocatur *Mercurius emeticus flavus*, vel *Turpethum minerale.*

13 Acidum marinum in Mercurium non agit viâ humidâ; at in vapores reſolutum, et ei per ſublimationem variis modis conjunctum, ſalem cryſtallinum ſemipellucidum conſtituit; qui vocatur *Mercurius ſublimatus corroſivus*, tunc viribus rodendi maximis pollens, cùm proportio Acidi, reſpectu habito ad Mercurium, fit maxima.

14 Mercurius ſublimatus, maximè corroſivus, cum ea quantitate Mercurii crudi tritus quæ ſufficiat Acido marino perfectè ſaturando, et ſublimatus fit opacus, aqua non ſolubilis, vis rodentis expers, et *Mercurius dulcis ſublimatus* nuncupatur.

15 Acida vitriolica et marina iis qui Propoſitionibus 12ª et 13ª explicantur modis cum Mercurio uniuntur. Quòd ſi Acida hæc vel Solutio ſalis cujuſlibet

medii, in quo alterutrum continetur, in Mercurium Acido nitri ſolutum infundantur, Mercurius ſeſe iis adjunget et pulveris albi forma præcipitabitur. Pulvis hic, ſi cum Acido vitriolico conjungatur, fit *Turpethum minerale*; ſin ab Acido marino præcipitatio fiat, *Mercurius præcipitatus albus* vocatur, ſublimato corroſivo vel dulci accedens prout ſit vel non ſit edulcoratus.

16 Mercurius ſublimatus corroſivus, aqua ſolutus, ab Alkali fixo in fundum præcipitatur in forma pulveris rubri: ab aqua calcis præcipitatus fit flavus: ab Alkali volatili albus: a miſtura Alkali fixi et Alkali volatilis paribus quantitatibus albor nihil inquinatur.

17 Spiritus vini rectificatus, et ebulliens, ſuum pene pondus Sublimati corroſivi; ad gradum 16^{m} Thermometri Reaumeri aut 68^{m} Fahrenheitii calefactus, tres octavas ponderis ſui partes, diſſolvit.

18 Spiritus vini rectificatus, ad gradum 68^{m} Thermometri Fahrenheitiani calefactus, et Sale Ammoniaco ſaturatus, Sublimati corroſivi tres quartas ponderis ſui partes diſſolvit: et proinde

vis ejus ſolvendi Sublimatum corroſivum Salis Ammoniaci additione duplicatur.

19 Aqua, cum ebulliat, dimidium ſuum pondus de ſublimato corroſivo; ſi ad quinquageſimum tantùm gradum Ther. Fahren. calefiat, vix partem ſui ponderis vigeſimam, diſſolvit.

20 Aqua, Sale Ammoniaco ſaturata et ad prædictum gradum calefacta, Sublimati corroſivi duas tertias partes ponderis ſui diſſolvit: et proinde majorem habet vim ſolvendi hunc ſalem quam aqua ſimplex in proportione fere, 40 : 3.

21 Si Mercurius cum Sulphure teratur, aut cum Sulphure liquato miſceatur, pulverem fuſcum, cito in nigrum abeuntem, conſtituit; qui vocatur *Æthiops mineralis.* Hic autem ſublimatione fit maſſa rubra, friabilis, ſtriata, quæ *Cinnabaris factitia* nuncupatur; a Cinnabari nativa, quando debita ſulphuris portio adhibita fuerit, vix diſtinguenda.

22 Si Cinnabaris factitia, aut nativa, miſceatur cum Alkali fixo, Calce viva, Limatura ferri, aliiſve rebus, quibus

major cum Sulphure competit affinitas, quam ipſe habet Mercurius, et diſtilletur, *Mercurius* obtinebitur *purgatus*. Aliquid etiam Sulphuris quod ab Acidis præcipitari poteſt a cinnabari, ea cum Alkali fixo decoquenda, extrahitur.

23 Mercurius Plumbum, Stannum et Aurum facillime penetrat et friabilia reddit; et cum omnibus quidem Subſtantiis Metallicis (Nickel et Regulo Cobalt forſan exceptis) quanquam cum Ferro, Antimonio et Ære paullò difficilius, vel trituratione frigida aut calida, vel fuſione, coit, Mixtura inde proveniens vulgò *Amalgama* rectius *Malagma* dicitur: quod eſt mollius, friabilius, fluidius, aut ſpiſſius pro diverſa quantitate Mercurii in eo conficiendo adhibiti.

24 Amalgama Mercurii et Argenti: gravitatem habet ſpecificam majorem gravitate ſpecifica ipſius Mercurii.

25 Acida vegetabilia et Sales alkalini eâdem fere methodo in Mercurium, quâ in Aurum et Argentum, agunt.

C A P. IV.

De Antimonio et ejus Regulo.

1 *ANtimonium crudum*, eſt Minera a terreis et lapideis recrementis Eliquatione purgata, ſtriis nitentibus tanquam aciculis ordinatim ferè diſpoſitis diſtinctum, atque ex Sulphure et parte metallica, quæ *Regulus antimonii* appellatur, paribus plerumque quantitatibus conflatum.

2 Antimonium crudum, igne mitiori uſtulatum, album copiosè emittit fumum; quem *Florum* nomine colligere licet. Reſiduum gradatim mutatur in Calcem cineream; quæ, igne fortiori fuſa, vitrum facit hyacinthini aut fulvi coloris, durum, volatile, eò pellucidius quò perfectior fuerat Calcinatio et tenuior Liquefactio.

3 Vitrum antimonii, cum aqua regia digeſtum, colorem ei rubeſcentem impertit: Acidis vegetabilium aut Vinis infuſum, abraſione quadam ſuæ ſubſtantiæ vim ipſis emeticam conciliat;

quæ tamen repetitis infuſionibus languefcere quidem et exhauriri dicitur.

4 Vitrum Antimonii, vel Antimonium crudum, tum lapides tum metallica omnia corpora (Auro et Platina exceptis) fuſione diſſolvit, et volatilia reddit: et hinc a quibuſdam vocatur *Lupus vorax*, *Balneum Solis*, &c.

5 Vitrum vel Calx Antimonii, cum Carbone, Sapone, aliâve ſubſtantia Phlogiſton continente fuſa, reducitur in Regulum; qui, ſi partium debita fiat refrigeratio, ſtellæ ſpeciem in ſuperficie plerumque exhibet.

6 Regulus Antimonii eſt Semi-metallum durum admodum et fragile, quod a Zinco et Biſmutho tum ſpecie externâ (quâ nec cæruleſcit, ut Zincum, nec flaveſcit, ut Biſmuthum) tum fuſilitate difficiliori diſtinguitur.

7 Regulus Antimonii, in igne aperto mitiori, fatiſcit in Calcem vitreſcentem; at in vaſis clauſis, valido igne fuſus, prorſus volatilis eſt; et Flores exhibet ſpiculorum ſplendentium inſtar, aqua ægriùs ſolubiles, igne vix volatiles, et in Regulum difficillimè reducendos.

8 *Regulus Antimonii conſici poteſt*, vel

Calcis reductione, ut in propoſitione 5^{a} explicatum eſt; vel Præcipitatione ſicca, qua nimirum interventu alterius corporis ſulphur a parte regulina ſeparatur; vel ſolutione humida partis metallicæ Antimonii crudi in Aqua Regia facta et Calcis inde dejiciendæ reductione.

9 Regulus Antimonii, cum Ferro, Stanno et Zinco fuſus, mixturas metallicas conſtituit quæ minorem habent gravitatem ſpecificam; cum Argento, Cupro, Plumbo, et Biſmutho, quæ majorem quam ſecundum regulas communes habere debent.

10 Reguli Antimonii cum acido nitri concocti aliquid diſſolvitur, at maxima ex parte in pulverem album corroditur: ſi cum Acido vitriolico diſtilletur corroditur quoque; Acidum autem fit ſulphureum, et Sulphur ſæpe ſublimatur. In Acido marino difficulter ſolvitur, facillime in Aqua Regia.

11 Si Regulus Antimonii, vel Antimonium crudum, cum ſublimato mercurii corroſivo trituratione probè miſceatur et diſtilletur, Acidum marinum

num in ſublimato Mercurium deferens, Regulo Antimonii ſeſe adjunget, et cum eo elevabitur, et in Excipulum tranſibit, vel collo Retortæ, pinguedinis glacialis aut Butyri ſpecie, adhærebit: unde *Butyrum Antimonii* nuncupatur. Aucto deinde igne, Mercurius vivus puriſſimus aſcendet, et in Recipiens decurret. Denique, ſi Antimonium crudum adhibeatur, Cinnabaris ſublimata in collo Retortæ invenietur.

12 Butyrum Antimonii aere deliqueſcit, et pulverem album deponit: repetitis diſtillationibus fit ex parte fluidum, et olei inſtar limpidum; ex parte, ſi rectè inſtituatur diſtillatio, ſublimatur cryſtallorum forma, in aere volatilium admodùm et deliqueſcentium.

13 Butyrum Antimonii, aquam affundendo, lacteſcit; et ob Acidum debilitatum, vel propterea quod Sales perfecte medii aqua vix ſunt ſolubiles, Regulus Antimonii in eo ſolutus maxima ex parte ad imum ſubſidet, ſpecie pulveris albi; qui, cum aqua ſæpius abluatur, inſipidus fiet; et vocatur

Pulvis Algaroth, vel (impropriè licet, cum nihil inſit Mercurii) *Mercurius vitæ*; qui, ſi fuſus ſit, vitrum ſuccinei coloris evadet.

14 Liquor poſt pulveris Algaroth præcipitationem remanens Butyri aliquid in ſe retinet ſoluti, quod evaporatione cryſtallos, diſtillatione ſalem ſublimatum in collo retortæ exhibet, aere non deliqueſcentem, ſpiritu vini ſolubilem, ſali ſedativo haud abſimilem. Ipſe liquor, ſed nullo jure, nuncupatur *Spiritus vitrioli philoſophicus*.

15 Si acidum nitri a Butyro Antimonii diſtillatione ſeparetur, Aqua Regia nonnullis forſan Reguli partibus inquinata obtinebitur, quæ vulgò dicitur *Spiritus Nitri bezoardicus*, a maſſa reſidua novi ſpiritus nitri abſtractione ſubſequente calcinatione et ablutione conficitur pulvis; qui dicitur *Bezoardicum minerale*.

16 Sal Alkali fixum tùm coctione tùm fuſione ex Antimonio crudo ſulphur ejus extrahit, et ſic *Hepar Sulphuris* conſtituit; quod partem regulinam Antimonii ſtatim diſſolvens hepar efficit Antimonii, colore hepatico vario, et aqua copioſius

aut parcius ſolubile, pro diverſis proportionibus quibus Alkali fixum et Antimonium una admiſceantur. Ex Hepate Antimonii Pharmaceutici parant medicamentum quod vocant *Crocum metallorum*, nec non *Vinum antimoniale*, *Tartarum emeticum*, &c.

17 Sulphur, quod ab Hepate Antimonii aqua ſoluto per Acetum aut Acidum quodcunque præcipitetur, *Sulphur Antimonii auratum* nuncupatur. Quod vero ſpontanea præcipitatione, dum frigeſcit ſolutio, dejicitur, *Kermes mineralis* aut *Pulvis Carthuſianorum* vocatur: Utrumque a ſulphure communi diſcrepat portione Reguli Antimonii quæ in eo continetur; a ſe invicem vero diſtinguuntur, tùm proportione partis regulinæ ad partem ſulphuream, quæ minor eſt in pulvere Carthuſianorum quàm in ſulphure aurato, tùm quòd Kermes mineralis alkali aliquid fixi ſibi adjunctum retinet.

18 Si Antimonium crudum nitro commiſceatur et deflagretur, maſſa reſidua, diverſis coloribus inſignis, diverſis medendi viribus valet; atque *Crocus Antimonii medicinalis* aut *Crocus*

Antimonii mitior, *Antimonii Calx diaphoretica*, &c. nominatur; pro variis proportionibus quibus Nitrum et Antimonium inter ſe miſceantur. Si ea quantitas Nitri adhibeatur quæ toti Sulphuris Antimonii deflagratione deſtruendo ſatis ſit, vis maxima emetica maſſæ reſiduæ comparabitur: ſin minori aut majori proportione admiſceantur, tum aut totum Sulphuris non erit abſumptum, aut pars etiam Reguli Phlogiſto ſuo privabitur. Utroque modo mitius fit medicamentum; quippe quòd vel ad Antimonii crudi, vel ad Calcis metallicæ, vires accedat.

19 Regulus Antimonii cum Sulphure liquatus in maſſam ſtriatam crudo Antimonio ſimilem frigore concreſcet.

C A P. V.

De Biſmutho.

1 BISMUTHUM eſt Semi-metallum cæteris Metallicis Subſtantiis (Stanno excepto) minore ignis gradu fuſile; inter Semi-metalla (Nickel excepto)

excepto) fixiſſimum; ponderoſum, fragile, ab aëre et aqua vix immutandum; Auri inſtar purum, non mineraliſatum, ſemper repertum.

2 Biſmuthum, in valido igne fuſum, fumum exſpirat inflammabilem; et, vel per ſe, vel cum additione, ſublimari poteſt in Flores flaveſcentes: In aperto et mitiori igne, mutatur facillimè in Calcem cineream; quæ continuata flammæ reverberatione flaveſcit, at vix niſi dum calida reſtat, rubeſcet. Calx in Vitrum liqueſcit, pellucidum, fuſcum, terrarum vitrificationi et uſibus docimaſticis apprimè accommodatum.

3 Acidum Nitri Biſmuthum diſſolvit magnâ cum Efferveſcentia et vaporum eructatione. Solutio, evaporata, præbet cryſtallos albas: affuſione aquæ puræ, Biſmuthum partim in ea ſuſpenditur; partim ab ea dejicitur; et pulvis ſic dejectus vocatur *Magiſterium Biſmuthi*, *Blanc d'Eſpagne*, vel *Blanc des perles*.

4 Acidum Salis marini, cum Biſmutho coctum, parum ejuſdem diſſolvit: Acidum Vitrioli nihil, quod præcipitari poteſt; at colorem rubeſcentem ab eo extrahit.

5 Si Acidum Vitrioli in Biſmuthum fuſum infundatur, vel ab eo abſtrahatur, ſulphuris aliquid colore fuſco ſublimatur, et odor arſenici, ſentitur.

6 Acida Vegetabilia aliquid Biſmuthi, quod ab Alkali præcipitari poteſt, coctione diſſolvunt. Alkalia fixa Phlogiſto imbuta, et alkalia volatilia, in Biſmuthum eodem fere modo, quo in Argentum, agunt.

7 Biſmuthum, cum Sulphure fuſum, cum eo coit et maſſam efformat ſtriatam, Antimonio crudo quodammodo ſimilem, et facile liqueſcentem.

8 Biſmuthum cum omnibus Metallicis Subſtantiis (Zinco et Nickel exceptis) ſeſe fuſione commiſcet et fluxiliora reddit: Stannum dealbat, durius, magis ſonorum, et fragilius ſimul efficiens.

9 Mercurius et Biſmuthum, paribus ponderibus unà fuſa, Amalgama ſolidum conſtituunt. Idem dici poteſt de Mercurio et Plumbo. At Mercurius, Plumbum, et Biſmuthum, paribus ponderibus, Amalgama efformant fluidum: ab hoc Biſmuthum, ſub ſpecie pulveris gryſei, brevi ſeparatur; at Plumbum

adeò tenuiter ſolutum reſtat, ut per Corium unà cum Mercurio tranſeat.

10 Aqua ebullit gradu caloris, in Thermometro Fahrenheitiano, 212°. Biſmuthum liqueſcit gradu 460°. Stannum liqueſcit gradu 410°. At Mixtura, ex paribus quantitatibus ſtanni et biſmuthi conflata, liqueſcit gradu 280°.

11 Si Plumbum, Stannum, et Biſmuthum unà fundantur paribus ponderibus, Maſſa mixta minori dicitur liqueſcere ignis gradu quàm eo quo aqua ebullit.

C A P. VI.

De Zinco et Lapide calaminari.

1 LAPIS *Calaminaris* tertiam vel majorem ponderis ſui partem, Florum ſpecie nec ſulphur nec arſenicum redolentium, uſtulatione amittit. Si cum pulvere carbonum permiſceatur, et igne vehementiſſimo vaſis quantùm fieri poterit clauſis diſtilletur, Subſtantiam præbebit Metallicam, ex cæruleo albam; quæ *Zincum* appellatur.

2 *Zincum* eſt Semi-metallum: vel ſtriatum, ut Zincum Goſlarienſe; vel teſſellis diſtinctum, ut Indicum et Anglicanum; durum; ſonorum, malleo (dum frigidum eſt) aliquantum cedens; in pulverem trituratione non reducendum; in igne liqueſcens ſimul ac rubet, at Plumbo difficilius; ſæpius fuſum, fit (Stanni inſtar) durius, fragilius, minùs fuſile, et calcinationi minus obnoxium: ab aëre et aqua non multùm mutatur.

3 Zincum, igne leniori fuſum, mutatur in Calcem: at ſi violentior ſit ignis, inflammatur cum ſtrepitu, et odorem emittit arſenicalem; flamma lucidiſſima, viridis, ne minima fuligine inquinata, durat donec tota Zinci maſſa ſit combuſta et in Flores albos, leviſſimos, Goſſypio ſimiles, (quos *Lanam* nuncupant *Philoſophicam)* ſublimata.

4 Zinci Flores ab Acidis omnibus diſſolvuntur; Phlogiſti additione, in vaſis clauſis *reducuntur*; in igne fixi reſtant, et in vitrum coloris praſini tandem convertuntur.

5 Acida omnia mineralia, nec non Acetum faciliori negotio Zincum quam

cætera Metallica Corpora diſſolvunt: Si cum Oleo vitrioli diſtilletur Sulphur ſublimatur, Reſiduum Arſenicum olet.

6 Zincum dum, ab Acido vitriolico aquoſo, vel ab Acido marino concentrato, diſſolvitur, Aerem, vel vaporem elaſticum, fœtidum, inflammabilem copioſe emittit; at nihil Sulphuris præbet.

7 Pondus totum Aeris inflammabilis, qui per ſolutionem Zinci in Acido vitriolico generatur, æquale circiter deprehenditur parti viceſimæ-quartæ ponderis ipſius Zinci.

8 Denſitas aeris inflammabilis fere eadem eſt ex qualicunque metallo, vel qualicunque Acido ſit genitus.

9 Aer inflammabilis, per Solutionem Zinci generatus, levior eſt aere communi (Thermometro denotante gradum 50 et Barometro 30 uncias) in proportione circiter 11 : 1.

10 Zincum in Acido vitriolico ſolutum, evaporatione concreſcit in Cryſtallos, quæ vocantur *Vitriolum Album* vel *Goſlarienſe*.

11 Zincum cum omnibus Metallicis Subſtantiis (Biſmutho excepto) fuſione

uniri poteſt. Paullò difficilius coit cum Ferro; facilius cum Cupro; cum reliquis facillime.

12 *Zincum* ab omnibus Metallicis Corporibus diſtinguitur; et ab iis depurgari poteſt: eò quòd cum Sulphure aut Hepate Sulphuris colliquefactum, nullam ab iis mutationem patitur.

CAP. VII.

De Cobalto et ejus Regulo.

1 SI Cobaltum uſtulatione in furno reverberii ab arſencio liberetur, in pulverem poſtea redigatur, et cum duplo vel triplo arenæ aut ſilicum calcinatorum et contuſorum miſceatur, mixtura aquâ irrorata in maſſam quaſi lapideam brevi indureſcit, et *Zaffera* vocatur.

2 Omnia Acida mineralia Zafferæ venalis aliquid diſſolvunt; acida vitrioli et nitri colorem fulvum aut roſeum ab ea extrahunt qui calore non mutatur; cum ab acido marino facta eſt ſolutio color ejus, dùm frigida manet, eſt fulvus

aut intenſe viridis prout acidum eſt aquâ dilutum necne; at dum caleſcit ſolutio fulvus mutatur in viridem.

3 Zaffera in acido vitriolico ſoluta, forma pulveris cærulei præcipitatur ab alkali fixo phlogiſto imbuto; ſi uberior alkali copia adhibeatur præcipitatum fit e cæruleo gryſeum quod tamen affuſione ſpiritus ſalis colorem cæruleum recuperat prorſus, uti evenire ſolet cum cæruleum Berolinenſe a ſolutione vitrioli viridis dejicitur.

4 Zaffera in acido vitriolico ſoluta gallarum decocto affundendo nigreſcit.

5 Zaffera ab acido quovis præcipitata, cum oleo aut ſevo miſta et igne leniter calcinata fit pulvis niger qui magneti obſequitur.

6 Zaffera igne liqueſcit in vitrum cæruleum, quod cum in pollinem ſubtiliſſimum reducitur vocatur *Smaltum* vel *Encauſtum cæruleum*.

7 Si Zaffera aut ſmaltum cum ſubſtantia inflammabili una fundantur, odor arſenicalis ſentitur, et ſubſtantia metallica in fundum præcipitatur quæ dicitur *Regulus Cobalti*.

8 Regulus Cobalti a reductione Zaf-

feræ ab acidis præcipitatæ vel ſmalti proveniens eſt fragilis admodum et durus, coloris gryſei, texturæ lævis at non granulatæ; a magnete promptiſſime atrahitur, calcinatione mutatur in pulverem nigrum qui ab igne vehementiori in vitrum cæruleum, ferri inſtar, liqueſcit.

9 In Regulum Cobalti, acida vitrioli et ſalis marini vix agunt; ſolutio in acido nitri facta eſt rubra, in aqua regia viridis.

10 Regulus Cobalti per Alkali fixum commune ab aqua regia præcipitatur in pulverem rubeſcentem, per Alkali phlogiſto imbutum in pulverem cæruleum.

CAP. VIII.

De Nickel.

1 NICKEL eſt Semi-metallum ex gryſeo rubens, cæteris minus fuſile, in calcem viridem mutabile, quæ in igne etiam fortiſſimo vix liqueſcet in vitrum.

2 Si Nickel et Biſmuthum una fundantur et ſub fuſione admiſceantur, Nickel conjunctionem cum Biſmutho, prorſus aufugiens ſemper ſupernatat, et Biſmuthum in imum ſubſidet.

3 Acidum vitriolicum ſive concentratum, ſit ſive aqua dilutum Nickel non diſſolvit: Acidum marinum paullo ſegnius in illud agit; Acidum nitri cum fumorum rubrorum eructatione violenter diſſolvit, ſolutio viret, et ab Alkali volatilis affuſione fit cærulea.

4 Dum Nickel ab acido nitri diſſolvitur, flocculi gryſei ab eo ſeparantur, qui in igne et ſulphuris et arſenici dant indicia.

5 Nickel ab acido nitri per alkali fixum præcipitatur in pulverem ſubviridem.

C A P. IX.

De Plumbo ſive Saturno.

1 PLumbum eſt Metallum imperfectum, minus quam cætera durum; elaſticum, tenax, et ſonorum;

Stanno minus fuſile: ab actione aeris et aquæ rubiginem quandam gryſeam contrahit, at difficiliùs corroditur quam Ferrum.

2 Filum Plumbi cylindricum cujus diameter decimæ parti unciæ æqualis eſt ſuſtinere poteſt pondus $29\frac{1}{4}$ Librarum.

3 Plumbum in igne fluit antequam candeſcit; aucto calore effumat et ebullit; fuſum in ſuperficie tegitur pelliculâ cintereâ verſicolore; quâ ſemotâ vel cum plumbo mixtâ, altera enaſcitur; et ſic tandem tota maſſa in Calcem converti poteſt quæ vocatur *Plumbum uſtum.* Hoc autem, Plumbo in hunc finem adhibito, levius eſt.

4 Plumbum uſtum, ſi ſubitam ignis violenti actionem patiatur, fit Olei inſtar fluidum, et in Scoriam convertitur vitreſcentem, ex ſquamoſis lamellis, flaveſcentibus aut rubeſcentibus, pro diverſo ignis gradu, conſtantem et *Lithargyrus* vocatur. Lithargyrus æquè ac Plumbum uſtum in igne mitiori diutiùs detentus, flammâ ſimul in ſuperficiem ejus ſupernè reverberatâ, fit primo flavus, deinde aureus et Gallico

idiomate a Pictoribus dicitur *Maſſicot*; tandem ruber, et vocatur *Minium*.

5 Maſſicot in igne calefactus fit e flavo ruber, frigeſcens iterum fit flavus.

6 Plumbum in Minium converſum, licèt multum de ſubſtantiâ ſuâ Florum formâ deperdat, pondere pluſquam decimâ parte augetur; at Minium illud nihilominùs, *Reductione factâ*, pondus æquale ponderi Plumbi ex quo erat confectum minimè præbebit.

7 Lithargyrus, Maſſicot, Minium aliæve Plumbi Calces facilè liqueſcunt in Vitrum coloris aurei.

8 Lithargyrus vel Vitrum Plumbi cum lapidibus, vel terris quibuſcunque refractariis fuſus, mirificè earum liquefactionem promovet; et Metallica corpora (Auro, Platinâ et Argento exceptis) in Scoriam vel Vitrum ſecum rapit: et hinc commodè adhibetur tùm ad Vitra conficienda pellucidiſſima, tùm ad Metalla perfecta a Mineris et Metallicis imperfectis purganda.

9 Plumbum ab Acido Nitri aquâ diluto copioſè diſſolvitur. Solutio evaporata in Cryſtallos concreſcit, albas, pyramidales, ſapore dulces, auſteras;

quæ in vaſe clauſo igni expoſitæ crepitant at non inflammantur.

10 Plumbum in Acido Nitri ſolutum, inde præcipitatur ab Acidis tum Vitrioli tum Salis marini quibus ſeſe conjunget: cum Acido marino ſic conjunctum Plumbum quod corneum vocant, cum Acido Vitrioli, Vitriolum Plumbi conſtituit.

11 Si Plumbum ſit cum Acido Vitriolico concoctum aliquanta ex parte diſſolvitur; Diſtillatione in vaſis clauſis inſtitutâ, totum corroditur in maſſam albam aquâ ex parte ſolubilem; vapor Sulphureus, qui inflammationem nonnunquam admittit, ſub fine exit, et Sulphur ſimul ſublimatur.

12 Si in Plumbum fuſum Acidum Vitriolicum infundatur, Sulphur communi prorſus ſimile ſtatim ſublimatur.

13 Si Plumbum ſit cum Acido marino coctum, exigua ejus pars ab Acido diſſolvitur. Solutio, debitâ factâ evaporatione, Cryſtallos ſiſtit, albas, pellucidas, Nitro haud abſimiles; vel cum adhuc calida ſit in aquam frigidam infuſa, præcipitatum præbet eximie album.

14 Acetum longâ digeſtione parum Plumbi diſſolvit; at in vapores reſolutum illud rodit in rubiginem ſquamoſam, friabilem, inſipidam, inodoram, quæ vocatur *Ceruſa alba.*

15 Ceruſa alba, vel Lithargyrus vel Minium ſi cum Aceto coquatur ab eo diſſolvitur. Quælibet harum ſolutionum uſque ad Mellis fère craſſitiem evaporata, Salem præbet cryſtallinum, dulcem, ſtipticum, venenoſum, dictum *Saccharum Saturni.* Quod diſtillatione ſpiritum ardentem præbet.

16 Olea Vegetabilium ſive Stillatitia ſive preſſa Plumbum integrum vel Calces ejus quaſlibet, (copioſiùs autem Minium) in coctione diſſolvunt. Solutiones ab Aceto poſſunt decomponi: et Olea preſſa ſic a Plumbo liberata Spiritu Vini fiunt ſolubilia.

17 Alkalia fixa per Calcem vivam acuata, parum Plumbi diſſolvunt, multum rodunt.

18 Si Calx quælibet Plumbi vel Plumbum integrum cùm Sulphure liquefiat, in Mineram, igne vix fuſibilem at naturali Plumbi Mineræ ſpecie perſimilem mutabitur. Plumbum cum

Arſenico fuſum in Flores partim ſublimatur, partim in Vitrum hyacinthinum mutatur.

19 Plumbum, cum omnibus ſubſtantiis Metallicis (Ferro excepto), per fuſionem commiſceri poteſt.

20 Si Mixtura Metallica ex Plumbo et Stanno confecta ſit fuſa cum ferro, Stannum (connubium Plumbi reſpuens) ſeſe Ferro adjunget.

21 Si Mixtura Metallica ex Ferro et Cupro vel ex Ferro et Argento conflata, ſit fuſa cum Plumbo, Cuprum vel Argentum Ferrum deſeret, et cum Plumbo in maſſam coibit.

22 Si Mixtura Metallica ex Plumbo et Stanno confecta ſit fuſa cum mixturâ ex Ferro et Argento conflatâ Stannum (Plumbum deſerens) ſeſe Ferro adjunget; et Plumbum ſimul Argenti connubium petit, et maſſas (utcunque ſub fuſione agitantur) diſtinctas, cum frigeſcunt, ſemper exhibebunt.

23 Plumbum ſcriptorium ſive Molibdæna, igne violentiſſimo occluſo, ferè nihil; igne aperto decimam quartam partem ponderis amittit. Reſi-

duum ne particulam præbet Plumbi at Ferri Magneti obedientis multum.

24 Plumbum ſcriptorium, in pollinem comminutum, cum Sulphure liquato intime coit et maſſam vix a verâ Minerâ diſtinguendam conſtituit; niſi quòd in flammà candelæ accenditur et ſumum Sulphureum exſpirat.

C A P. X.

De Cupro ſive Venere.

1 CUPRUM eſt Metallum imperfectum; Auro, Argento, Plumbo et Stanno magis durum et elaſticum, at in igne minus fuſile; Plumbo et Stanno magis ductile et fixum: et omnium maximé ſonorum.

2 Cuprum, diu candeſcens, tandem fluit; fuſum, fit humidi admodum impatiens; in aperto igne violentiori ſi detineatur, Pondus ejus diminuitur, Superficies comburitur et in Crocum ſubrubrum convertitur, qui ab igne ſolari denſato vitrum fit rubrum.

3 Ea eſt *Cupri tenacitas* ut filum

cylindricum, cujus diameter æqualis eſt decimæ parti unciæ, ſuſtineat pondo $299\frac{1}{4}$.

4 Cuprum ab omnibus Acidis, tùm mineralibus tùm vegetabilibus, diſſolvitur, nec non ab Alkali fixo et volatili, a Salibus mediis, Oleis expreſſis et eſſentialibus; ab ipſis Aere et Aquâ eroditur et in Æruginem mutatur: *frictu calefactum, odorem*; manducatum, ſaporem nauſeam moventem præbet.

5 Cuprum ab Acido Nitri facillimè diſſolvitur; ab Acido marino difficiliùs, ab Acido vitriolico difficillimè, niſi acidum ſit concentratum et ebulliens. Hæc Solutio cryſtallos dat, cæruleas, figura rhomboidales, in aere non deliqueſcentes, quæque *Vitriolum* conſtituunt quod a Mercatoribus *Romanum* aut *Cyprium*, vel *Cuperoſum cæruleum* vocatur.

6 Ab aquis cæmentatoriis ut vocantur, vel, quod eodem redit, a vitriolo cæruleo in aquâ ſoluto Cuprum puriſſimum præcipitatur additione ferri. Solutio vireſcit, acidò ferrum ſubeunte.

7 Si Cupri lamellæ ſint alternatìm ſtratæ cum vinaceis exſiccatis (quæ

cum vino generoſo per fermentationem in acetum abeunte aliquot dies priùs fuerint digeſtæ) erodentur, et ſuperficies ſingularum viridi-cærulea quadam cooperietur efflorefcentia, quæ *Ærugo* vel *Viride Æris* nuncupatur.

8 Cuprum vel Viride Æris venale (quod conſtat ex Cupro et Acido in proportione circiter 5 : 7.) ab aceto ſtillatitio ſolutum, dat per inſpiſſationem cryſtallos virides, aëre ſicco in pulverem fatiſcentes, quæ apud Mercatores impropriè dicuntur *Viride Æris diſtillatum*.

9 Viride Æris diſtillatum, dimidium penè ſui ponderis, Acidi admodum concentrati diſtillatione præbet, quod *Acetum radicatum* vel *Spiritus Veneris* vocatur.

10 Spiritus Veneris eſt aliquantùm volatilis, odorem exhalat ſuffocantem; igne Spiritus quemadmodum Vini, eſt inflammabilis; cryſtalliſationem admittit; et *Ætherem acetoſum* diſtillatione cum Spiritu Vini exhibet.

11 Reſiduum ex Spiritu Veneris præparatione in Cuprum reducitur per ſimplicem cum Borace fuſionem.

12 Si Cupri limatura et Sublimatum

Mercurii corroſivum unà diſtillentur, Acidum marinum Cuprum invadens, illud in maſſam reſinæ citrinæ vel rubræ ſimilem mutabit.

13 Cuprum ab Oleis vel Spiritu Vini ſolutum, vel in integro etiam ſuo ſtatu igne utcunque combuſtum, colorem viridem flammæ impertit.

14 Cuprum calcinatum, præcipitatum, ſulphuratum, qualicunque demum modo paratum, vel etiam integrum vitro miſtum et ſine additione fuſum, colore viridi vitrum imbuit.

15 Si Cuprum ſit cum Lapide Calaminari aliâve Zinci Minerâ, debitâ adhibitâ encheireſi colliquefactum, pondere, ad tertiam vel majorem ponderis totius partem, augebitur. Mixtura Metallica flava conflabitur, quæ *Aurichalcum* vocatur.

16 Aurichalcum frigeſcens Cupri malleabilitatem habet; igne calefactum fit fragile; ſed levius, durius, fuſilius, magis ſonorum, ſcorificationi in igne mitiori, actioni aëris et aquæ ipſo Cupro minus obnoxium deprehenditur.

17 Aurichalcum in igne diutius fuſum mutatur in Cuprum; quippe Zincum

cum ſive pars metallica Lapidis Calaminaris comburendo diſſipatur.

18 Aurichalcum, cum Mercurio trituratione amalgamatum, mutatur in Zincum: quippe Cuprum, reſtante Zinco, Mercurio adjungitur.

19 Cuprum, cum Zinco liquatum in proportione 4 : 1. vel ſecundum alias proportiones, Mixturas varias Metallicas conſtituit, colore Auro perquam ſimiles, at propter Zinci impuritatem plerumque fragiles; quæ vocantur *Metalla Principis Ruperti*, *Metalla aurea ſophiſtica*, *Metalla Tombacina*, &c.

20 *Cuprum album* conficitur ex Cupro colliquefacto cum Arſenico per Nitrum fixo. Sæpiùs fuſum pondere diminuitur parte circitèr ſeptimâ, in Cuprum rubrum mutatur et ſub fuſione odorem efflat arſenicalem.

21 Si Cuprum et Stannum, quibus pauxillum Aurichalchi aut Biſmuthi nonnunquam adjicitur, per fuſionem commiſceantur, Mixturam Metallicam conſtituent ſubflavam, duram, ſonoram, fragilem, Aeris et Aquæ actioni ipſo Cupro longe difficilius cedentem; quæ vocatur *Metallum tormentorum bellicorum*,

rum, *Campanarum*, *Æs Caldarium*, *Bronze*, &c. pro varia proportione quibus Cuprum et Stannum unà liquantur.

22 Si æquales magnitudines Cupri et Stanni unà fundantur, Mixtura ex his conflata minor erit, parte pluſquam quarta, quam cuprum et ſtannum ſimul ſumpta; pondus tamen haud mutabitur, et gravitas ſpecifica fiet ipsâ Cupri gravitate ſpecificâ major.

C A P. XI.

De Ferro ſive Marte.

1 *FERRUM* eſt Metallum imperfectiſſimum; aëri et aquæ expoſitum, omnium facillime rubigine exeditur; cæteris, (Platinâ exceptâ) minùs fuſile, et (excepto Cupro) magis ſonorum; duritie et elaſticitate omnia exſuperat; et unicum eſt quod a Magnete atrahitur.

2 Ferri Filum cylindricum, cujus Diameter decimæ parti unciæ equalis eſt, ſuſtinere poteſt pondus 450 Librarum. Hinc Ferrum videtur omnium

Metallorum eſſe tenaciſſimum. Nam tenacitas non videtur eſſe menſuranda ponderibus quibus diſrumpantur fila metallica earumdem Diametrorum, ut aſſolet, ſed quibus cohæſio datarum Quantitatum materiæ ſuperatur; vel ponderibus, quibus fila, cujus Diametri ſunt in reciprocâ ſubduplicatâ ratione gravitatum ſpecificarum, diſrumpuntur.

3 Ferrum, violentiori motu attritum, candeſcit; igni fortiori expoſitum, in ſuperficie quodammodo vitreſcit; ad fuſionem accedens ſcintillat, fumum vel flammam quaſi Sulphuream emittit, et in calcem mutatur: at in clauſo vaſe Calcinationem non patitur.

4 Si Ferrum excandeſcens follium continuo flatu urgeatur, Calor ejus augebitur et liqueſcet.

5 Ferrum ab Acido vitriolico aquoſo facillimè diſſolvitur. Solutio hæc evaporata Salem præbet, viridem, rhomboidalem, qui vocatur *Sal Martis, vitriolum* vel *Cuperoſum viride.*

6 Ferrum duriſſimum, ſub aqua vitriolica per plures Annos ſubmerſum, fit, ut dicitur, mollitie et Colore Molibdenæ perſimile.

7 Acidum nitroſum agit violentèr in Ferrum; marinum paullò ſegniùs; utrumque cum eo Salem deliqueſcentem efficit; qui, cùm Acidum marinum adhibetur, in Spiritu Vini eſt maximâ ex parte ſolubilis.

8 Acida omnia Vegetabilia, tùm nativa tùm fermentatione generata, nec non Sal Ammoniacus, Sales Alkalini, Aqua, et Aer, agunt in Ferrum et varia inde Pharmaceuticis ſuppeditantur medicamenta. Horum præcipua ſunt 1° *Croci martiales* vel *Calces Ferri*, colore rubro aut flaveſcente tinctæ, ſive parantur Calcinatione, Præcipitatione, vel ſimplici Actione Aquæ, vel Aquæ et Aeris conjuncta. 2° *Tincturæ martiales*, vel Ferrum variis modis in Spiritu Vini ſolutum. 3° *Flores martiales*, vel Ferrum cum Sale Ammoniaco ſublimatum. 4° *Lixivium Martis*, vel Reſiduum a Sublimatione Ferri cum Sale Ammoniaco quod in liquorem deliquio redactum eſt. 5° *Vinum Chalybeatum*, vel Ferrum in vino Rhenano digeſtione ſolutum. 6° *Rotuli martiales*, et *Tartarus Chalybeatus*, vel Ferrum cum Tartaro conjunctum, &c.

9 Limatura ferri aquâ madefacta ſæpius et exſiccata, in Rubiginem tota convertitur, pondere augetur, et *Salem volatilem*, ut dicitur, diſtillatione exhibet.

10 Cum Ferrum in Acido vitriolico vel marino diſſolvitur, vapor elaſticus, fœtens, ſulphureus generatur; qui admotione Candelæ inflammatur.

11 Si partes æquales Scobis ferreæ et Sulphuris vulgaris in mortario triturentur, et in paſtam aqua formentur, Mixtura, paucis elapſis horis, incaleſcit, turgeſcit, vaporem ſulphureum expirat, et ſi quantitas ſit ſatis magna, flammam ſponte concipit.

12 Ferrum candens cum Sulphure facillimè coit, et ab eo reducitur in Speciem Mineræ aere efflореſcentis, Pyritæ martiali efflorеſcenti perſimilis.

13 Ferrum, uberiori Phlogiſto imbutum, mutatur in *Chalybem*.

14 Chalybs, Phlogiſto ſuperabundanti privatus, mutatur in ferrum. Quær. Utrum Phlogiſton ſit unicum Principium, ex cujus majore vel minore copiâ pendet inter Ferrum et Chalybem diſcrimen?

15 Chalybs, igne calefactus et aqua frigida ſubitò immerſus, fit durus admodum et fragilis ; et ſic a ferro diſtinguitur, æquè ac majori ſuâ gravitate ſpecificâ, fuſilitate in igne faciliore, elaſticitate majori, Colore magis nigricante, et textura magis compacta, quæ ex granis exiguis, diverſarum in diverſis Generibus magnitudinum conſtat.

16 Chalybs expolitus, per diverſam ignis actionem, diverſos exhibet Colores. Primò flaveſcit, deinde flavet, rubeſcit, purpuraſcit, liveſcit, nigreſcit, tandem aucto adhuc igne candeſcit.

17 Chalybs, igne candefactus, et immerſione in aquam induratus, duritiem ſuam gradatim amittit dum colores diverſos prædictos ſuſcipit ; et ex hac coloris mutatione de duritie inſtrumentorum quæ ſingulis operibus conveniat judicium ferunt opifices.

18 Ferrum in Acidis ſolutum adfuſione decocti Gallarum (ſi ſolutio ſaturetur) nigreſcit, et lente in fundum ſubſidet, ſpecie nigri pulveris ; qui ab acido maximâ ex parte iterum diſſolvi poteſt.

19 Ferrum in Acido vitriolico ſolutum,

tum, inde præcipitari poteſt Alkali fixo quod phlogiſto qualicumque ſaturetur idque ſub formâ pulveris cærulei; qui a pictoribus nuncupatur *Cæruleum Bærolinenſe.*

20 In Cæruleum Bærolinenſe Acida non agunt: Alkalia fixa materiam colorantem ab eo extrahunt, et eâ ſaturari poſſint.

21 Alkalia fixa, cum Materia colorante Cærulei Bærolinenſis ſaturata, cum Acidis non effervеſcunt; colorem Cæruleum Vegetabilium non virideſcunt; et Ferrum, in Acido quocunque ſolutum, ſub cæruleo colore præcipitant.

22 In omni ferè Arenâ, in Argillis coloratis, in Lapide Lazuli, in pleriſque lapidibus pretioſis, in cunctorum ferè Vegetabilium cineribus, in Craſſamento ſanguinis, in Urinâ, et in carne Animalium, in cineres redactis, vel etiam leni calore exſiccatis, particulæ plurimæ reperiuntur quæ a Magnete attrahuntur.

23 In Oſſibus Animalium, in pinguedine, et parte ſanguinis ſeroſâ, calcinatis, vel nullæ vel perpaucæ depre-

henduntur particulæ Magneti obſequentes.

24 Particulæ quæ Magnetis Vim patiuntur plures reperiuntur in ſanguine Hominum et Quadrupedum, quàm in Sanguine Piſcium; et plures in Sanguine Piſcium quam Volatilium: et, in genere, quò uberior ſit Globulorum rubrorum in ſanguine innatantium copia, eò major deprehenditur quantitas particularum, Magnetis actioni obedientium.

25 Particulæ, a cineribus magnete ſeparatæ, Acidis diſſolvi nequeunt.

26 Ferrum, cum Plumbo fuſum, omne cum eo reſpuit conſortium, et ei perpetuo ſupernatat: at aliis Metallicis Subſtantiis (zinco forſan, quod calorem debitum ſuſtinere nequeat, excepto) facile per fuſionem coit, et Mixturas varias Metallicas conſtituit: Hæ autem, ſi ejus cum Regulo Antimonii (ob Sulphur forſan, quo Regulus inquinatur) mixturam excipias, Magnetis attractionem patiuntur.

27 Ferrum cum Mercurio vix amalgamari poteſt, at ſub eo nihilominus per aliquot Dies ſubmerſum, vel va-

pori Mercuriali expoſitum fit, ut dicitur, fragile et friabile.

28 Ferrum materia vitreſcente per fuſionem mixtum, minore ignis gradu viridem, majore cæruleum ei ſemper impertit colorem.

CAP. XII.

De Stanno ſive Jove.

1 STANNUM eſt metallum imperfectum, præ cæteris metallis levius et in igne fuſilius; at, Plumbo excepto, minima duritie, tenacitate, elaſticitate, ſono gaudens: Stridor quidam inter plicandum, ei, Zincum ſi excipias, eſt proprius; aëris et aquæ actioni parum profecto cedit.

2 Stanni filum cylindricum, cujus diameter decimæ parti unciæ æqualis eſt, ſuſtinere poteſt pondus 49 Librarum.

3 Stannum uſque fere ad fuſionem calefactum, vel poſt fuſionem frigeſcens et in ſolidum tantum non condenſatum, fit rigidum admodum et fragile, et ſi motu velociori in eo

ſtatu conquaſſetur in granula minuta, poroſa erit divulſum. Plumbum et Aurichalcum ſimilem ſubeant comminutionem, at Aurum et Argentum quæ fuſioni proxima fiunt tenaciora, Granulationem ea methodo non admittunt.

4 Stannum fuſum odorem exſpirat arſenicalem, ſcintillas emittit, et in calcem albeſcentem, difficilime reducendam, et in foco etiam ſpeculi uſtorii vix vitrificandam, citò calcinatur.

5 Stannum in igne fortiſſimo diutius detentum dicitur partim in flores ſublimari, partim in calcem rubeſcentem redigi, partim in vitrum pellucidum coloris rubei mutari.

6 Stannum et Plumbum una fuſa turgeſcunt, et lucida quaſi combuſtione citius in cineres exuruntur, quam ſingula ſeorſim calcinata.

7 Si Calces ſtanni et plumbi cum ſilice calcinato vel vitro pellucidiſſimo contuſo et ſale alkalino fixo ſimul fundantur, maſſam vitreſcentem lacteam in arte fictili et encauſtica utiliſſimam conſtituent; cui ſi calces aliorum me-

tallorum conjungantur, encauſta varia diverſimode colorata conficientur.

8 Si ſtannum cum Acido vitriolico concentrato uſque ad ſiccitatem in vaſis clauſis diſtilletur, multum exibit vaporis ſulphurei qui inflammationem nonnunquam admittit, et ſulphur ſimul in collo retortæ ſublimatum invenietur. Quod ſi acidum ſit aqua dilutum, vapor eſt ſemper fere inflammabilis, et ſulphur præcedente, ut videtur, minus flavum et in minori copia generatur.

9 Stannum in acido vitriolico aquoſo copioſe diſſolvitur; ſolutio, debitâ factâ evaporatione, cryſtallos præbet albas, tenues lanugini ſimiles, quas *Vitriolum Jovis* nominare liceat.

10 Stannum ab acido marino calefacto et concentrato promptius diſſolvitur, et vapor inde inflammabilis ſulphur et Arſenicum redolens producitur, cujus pondus æquale circiter deprehenditur parti quadrageſimæ quartæ ponderis Stanni ſoluti.

11 Si Stannum cum Sublimato mercurii corroſivo diſtilletur, primo in excipulum cadent guttulæ quædam acidi marini, deinde prodibit liquor eximiè

fumans,

ſumans, qui *Liquor fumans Libavii* dicitur (in æthere marino conficiendo utiliſſimus), tandem in collum retortæ ſtannum cum acido marino conjunctum ſub forma ſolida elevabitur.

12 Stannum ab acido nitri promptiſſime diſſolvitur, vel potius ni cautè inſtituatur ſolutio in calcem corroditur: Ab aqua regia ſolutio ejus facillime abſolvitur; hæc ſolutio eſt coloris et ſpiſſitudinis variæ, haud raro in ſolidum, juris inſtar gelati, concreſcit.

13 Stannum in aqua regia ſolutum, ſub leni evaporatione arſenici plerumque cryſtallos exhibet: quod ab imperfecta mineræ calcinatione provenire cenſendum eſt, cum datur ſtannum ab omni arſenico immune.

14 Stannum in acido nitri vel in aqua regia ſolutum, et cum purpuraſcentibus decoctionibus Ligni Braſiliani, Cochinellæ, &c. mixtum, colores earum in uſus tinctiles eximie exaltat.

15 Si Stannum, argentum vivum, ſulphur, et ſal ammoniacus accuratè admiſceantur, ac in igne forti ſublimentur, ſuperiora vaſorum petet quæ-

dam Cinnabaris, in imo remanebit maſſa levis, friabilis, coloris aurei, quæ vocatur *Aurum Muſivum* vel *Muſicum*, quod phlogiſti additione in ſtannum reducatur.

16 Stannum in Aceto, vino Rhenano, et ſuccis nativis acidis vegetabilium diſſolvi poteſt.

17 Stannum cum omnibus metallicis corporibus facillime fuſione commiſceri poteſt; fragilia (ob arſenicum forſan quo inquinatur) reddit, et difficillime ab iis ſeparatur.

18 Stannum cum plumbo colliquatum fit rigidius; fuſum cum Biſmutho, Zinco, Regulo Antimonii, &c. fit magis durum, album, et ſonorum.

19 Stannum foliatum cum mercurio facillime in Amalgama coit, quo ſuperficies poſteriores ſpèculorum planorum obduci ſolent.

20 Si Stannum, Plumbum, et Biſmuthum una fundantur, et cum Mercurio commiſceantur, Amalgama conſtituent ad ſuperficies concavas obtegendas apprime idoneum.

21 Stannum fuſum cupri et ferri non tantum ſuperficiei adhæreſcit, ſed

in intimiora penetrat, ut videre licet in ferreis inſtrumentis quibus opifices utuntur ad laminas ferreas ſtanno illinendas.

C A P. XIII.

De Argento ſive Lunâ.

1 *ARgentum* eſt Metallum perfectum; ductilitate et fixitate Auro proximum; fluit cum primùm candeſcit, et paullo facilius quam Ferrum, Cuprum et Aurum: Aurum, Plumbum et Stannum duritie et elaſticitate ſuperat; omnibus Metallis (Cupro excepto) magis ſonorum eſt; actione aëris et aquæ prorſus immutabile, at a Sulphureorum halitu infuſcatur.

2 Argentum, ut ait Kunckelius, igni vehementiſſimo furni vitriarii per menſem expoſitum, 64ª circiter ponderis parte diminutum deprehendebatur; ſpatio duorum menſium, ut ait Gaſtus Clavius, decrementum ponderis in eodem igne patiebatur æquale parti duodecimæ ponderis totius; ut ait Hombergius, vitro uſtorio expoſitum in fu-

mum abiit, ſed in Vitrum non fuit converſum.—Annon ponderum decrementa ignobili alicui Metallo quod cum argento miſceatur, potius quam defectui fixitatis in Argento ipſo, attribui debeant?—Annon fumus, quem obſervavit Hombergius, ipſi Argento in Auras acto, potius quam Argento in partes diſſimiles reſoluto, referendus eſt?

3 Ea eſt *Argenti tenacitas*, ut filum Cylindricum, cujus diameter æqualis eſt decimæ parti unciæ, ſuſtinere poteſt pondus 270 Librarum.

4 Argentum non ſolvitur in Acido Salis marini, viâ humidâ, nec in Aquâ regiâ; difficillimè quidem in Oleo Vitrioli, etiam ebulliente; promptiſſime verò in Acido Nitri ſolvitur. Solutio in Acido Nitri facta, ſi depuratum ſit Argentum, eſt pellucida, excolor, amara, cauſtica.

5 Solutio Argenti, in Acido Nitri facta, Capillos, Cutem, Oſſa, cæteraque Animalium ſolida, nec non Achatem, Jaſpidem, plureſque alios lapides fuſco vel nigro colore tingit: evaporatione in Cryſtallos concreſcit albas, quæ in igne fuſæ colorem induunt nigrum,

grum, et maſſam cauſticam conſtituunt quæ vulgò dicitur, *Luna cauſtica* vel *Lapis infernalis*; quæ vi minori, aut majori, cauſticâ pollet, prout Solutio eſt penitus, vel ex parte, ſaturata.

6 Argentum, ex ſolutione ſuâ in Acido Nitri præcipitatum, fit ſolubile, per Acidum vegetabile, vel nativum, vel ex fermentatione generatum: per Alkali volatile et Alkali fixum, quod conficitur calcinando Sale alkalino fixo, cum ſanguine bovino: ſed nec per Alkali fixum commune, vel cauſticum, vel Calcinatione cum Carbone vegetabili paratum, nec per Nitrum fixum detonatione cum carbone vegetabili aut animali. Hoc autem deſtectui ſalis alkalini volatilis quo alkali fixum ſanguine bovino calcinatum imbuitur, attribui forſan poteſt.

7 Si in Solutionem Argenti Acido Nitri factam, infundatur Acidum vitrioli, vel Salis marini, vel Solutio cujuſlibet Salis, hoc vel illud Acidum continentis, Argentum deſerat Acidum Nitri, et cum Acido vitrioli vel Salis marini conjunctum, Coaguli inſtar albi, in fundum ſubſidet.

8 Argentum,

8 Argentum, cum Acido marino conjunctum et igne fuſum, fit Corpus admodum volatile; ex parte pellucidum et quaſi corneum; et exindè *Luna cornea* appellatur: quæ in aquâ vix ſolvitur, et quinta circiter parte, accretione Acidi, Argento ſoluto ponderoſior eſt.

9 Si Argentum ſit cum Acido vitriolico uſque ad ſiccitatem diſtillatum, vapor prodit ſulphureus, at nihil ſulphuris ſublimari obſervatur; ipſum Argentum in maſſam duram flaveſcentem, aquâ maximâ ex parte ſolubilem, et Cryſtalliſationis capacem convertitur.

10 Si in Argentum fuſum Acidum vitriolicum infundatur, vapor prodit eximie ſulphureus; at Sulphur non ſeparatur.

11 Argentum ab omnibus Metallicis Subſtantiis (Auro et Platinâ, et perparvâ forſan Cupri quantitate exceptis) Cupellatione liberatur. In Acido Nitri ſolutum, et inde ab Acido marino præcipitatum, fit, reductione factâ, ab omni Corpore heterogeneo immune et puriſſimum habetur.

12 Argentum, cum Sulphure fuſum, in Maſſam fragilem convertitur, colore et mollitie plumbi ſimilem. Hâc fuſione minima pars Auri a Maſsâ quâlibet Aigenti ſeparari poteſt.

13 Argentum, cum Cupro Colliquefactione conjunctum, fit magis durum et ſonorum. Quod ſi cum Stanno vel Regulo Antimonii conjungatur, pene omnem ſuam Malleabilitatem perdit.

14 Argentum purum ponitur æquale duodecim denariis. Si ejus pars duodecima ſit Cuprum, vel aliud imperfectum metallum, dicitur conſtare ex undecim denariis; quale eſt Argentum ex quo *Ludovici* cuduntur. Argentum Anglice dictum *Sterling* conſtat ex undecim denariis, unà cum decimâ denarii parte; ſive Cuprum eſt ad Argentum ut 3 : 37, in Monetâ noſtrâ.

15 Argentum vel ſulphuratum, vel præcipitatum vel integrum, cum Vitro cryſtallino fuſione intime mixtum, vel Cæmentatione utcunque conjunctum, colorem flavum ei ſemper impertit.

C A P. XIV.

De Auro ſive Sole.

1 AURUM eſt Metallum perfectiſſimum, coloris inter fulvum et ſubflavum varii; cæteris metallis, plumbo et ſtanno exceptis, minus elaſticum, durum, et ſonorum; plumbo, ſtanno, et argento minus fuſile; fixitate, pondere, et ductili extenſione omnia exſuperans; actione aëris et aquæ mutabile.

2 Aurum in igne vehementiſſimo furni vitriarii per plures hebdomadas liquefactum, nullam aut calcinationem aut partium diſſipationem patitur: ab igne ſolari condenſato, in auras diſſipatur, at nec in vitrum violacei coloris nec in partes diſſimiles, ab illo etiam ignis gradu, converti videtur.

3 Aurum in igne candeſcens funditur, fuſum colorem cæruleo-viridem induit, cæteris metallis mole magis augeri videtur; non ſatis fuſum vel ſubito nimis refrigeratum, fit malleo

paullò intractabilius, at a carbonum vaporibus fragile non redditur.

4 Auri filum cylindricum, cujus diameter decimæ parti unciæ æqualis eſt, ſuſtinere poteſt pondo 500.

5 Aurum cum Borace fuſum, fit ſolito pallidius, refuſum cum nitro colorem ſuum recuperat.

6 Poſito quod gravitas ſpecifica aquæ diſtillatæ et ad gradum 53^m Therm. Fahren^i. calefactæ ſit 1,000, gravitas ſpecifica auri purgatiſſimi haberi poteſt 19,376.

7 Auri reliquorumque metallorum etiam puriſſimorum gravitates ſpecificæ intra certos limites variæ erunt, propter et diverſam gravitatem abſolutam, et diverſam expanſionem aquæ, quâ in diverſis locis et diverſâ cæli temperie ponderantur.

8 Aurum cum omnibus ſubſtantiis metallicis per fuſionem commiſceatur.

9 Mixtura auri et ferri in minori fluit ignis gradu, quam ferrum ipſum, et inde fit idonea ad ferri fracturas ferruminandas.

10 Mixtura auri et cupri fuſilior eſt quam aut aurum aut cuprum, et inde utrique fit idoneum ferrumen.

11 Aurum cum Subſtantia quacunque Metallica colliquatum fit minus ductile; ab Argento et Cupro malleabilitas ejus minimè diminuitur, maxime autem vel potius auſertur perparvis quantitatibus Plumbi aut Stanni, vel etiam ſi vaporibus ſolum, quos fuſa emittunt, bilance non dignoſcendis ſit expoſitum.

12 Aurum ut moneta fiat, atque ut aliis uſibus Oeconomicis inſerviat, durius reddi ſolet mixturâ parvarum quantitatum aliorum metallorum, Argenti præcipue et Cupri, vel amborum conjunctim.

13 Maſſa quælibet auri in partes viginti quatuor, quas Ceratia vocant, dividi ſemper concipitur; et dicitur Aurum obryzum; Aurum caraticum tria et vicenarium, ut Aurum Ducatorum; Aurum caraticum duo et vicenarium, ut Aurum in Anglia dictum *Standard*, et ſic deinceps, prout Aurum ſit ab omni mixtura heterogenea illibatum, vel una, duabus, et ſic deinceps partibus vigeſimis quartis alterius alicujus metalli inquinatum.

14 Aurum, in integro ſuo et naturali ſtatu, hucuſque ſolubile non deprehenditur ab ullo acido ſimplici, ſulphure, alkali fixo vel volatili: ſed ab aqua regia, et hepate ſulphuris diſſolvi poteſt.

15 Aurum cum Argento colliquatum, ab acido marino, debita ſi adhibeatur Encheireſis, diſſolvi dicitur.

16 Aurum in aqua regia ſolutum, et exinde per Alkali fixum præcipitatum, ab omnibus acidis tum mineralibus tum vegetabilibus diſſolvi poteſt, nec non a ſale Alkalino volatili, et fixo, qui conficitur methodo in propoſitione 6ª de Argento explicata.

17 Aurum ab aqua regia per Alkali fixum aut volatile dejectum, et leni calore ſiccatum, vocatur *Aurum fulminans*, eo quod ſive ab igne ſive affrictu incaleſcat, cum magno fragore in auras diſſipatur: Hanc autem fulminandi vim, niſi Alkali volatile vel in confectione aquæ regiæ vel in præcipitatione adhibeatur, non acquirit.

18 Pondus Auri fulminantis majus eſt pondere auri ſoluti, parte circiter quarta.

19 Aurum fulminans cum diſplodatur, cavitates imprimit laminis metallicis non nimium craſſis quibus imponitur, vel quibus ſupernè premitur, et non deorſum tantum ſed quaquaverſum vires ſuas exerit.

20 Vis Elaſtica Auri fulminantis, dicitur eſſe ad vim elaſticam pulveris pyrii ut 64 : 1.

21 Aurum fulminans in Sphærâ ferreâ exactiſſime obturatâ incluſum, ac igni expoſitum non diſploditur; in ſimili caſu pulveris pyrii facta eſt exploſio, et ſphæra ſimul diſrupta invenitur.

22 Aurum fulminans aqua ſæpius lavatum, cum oleo vitrioli tritum, cum ſulphure fuſum, vel ab alkali fixo lixatum, vim ſuam fulminantem amittit.

23 Aurum nec per calcinationem cum vel ſine additione, nec per ſolutionem in aqua regia, nec per ſublimationem, nec per exploſionem, nec per ullam aliam methodum hucuſ-

que repertam, in partes diſſimiles reſolvatur.

24 Aurum in aqua regia ſolutum cutem et plures ſubſtantias animales ac vegetabiles rubro vel purpureo colore tingit, debita facta evaporatione, in cryſtallos concreſcit rubras, et quacunque methodo, metallico ſuo aſpectu ſit privatum, et ad pulveris ſpeciem redactum, colorem magis minuſve rubicundum plerumque adipiſcitur.

25 Aurum, metallorum denſiſſimum, cum vitro puro cryſtallino colliquefactione confuſum, vitri denſitatem adaugendo, aptum illud reddit ad reflectendos radios minime refrangebiles, et ſemper vitrum præbet rubro colore pellucidum.

26 Aurum a menſtruo ſuo extrahitur atque per aliquod tempus ſuſpenſum tenetur Oleis Eſſentialibus; facillime autem ſeparatur Æthere vitriolico, et cum unicum ſit metallum cui hæc proprietas competit, ſi cum cæteris vel minima quantitate commiſceatur, hoc indicio deprehendi poteſt.

27 Aurum in aqua regia ſolutum inde præcipitari poteſt (ſi multa aqua diluatur ſolutio) vel laminis Stanni, vel ſolutione Stanni in eodem menſtruo factâ, ſub forma pulveris coccinei qui vulgo vocatur *Caſſii purpureum Magiſterium.*

28 Una Auri ſolutionis guttula, per aliquot aquæ uncias diffuſa, Stanni interventu colorem purpureum toti aquæ conciliat, et ſic ab omnibus Subſtantiis metallicis quibus admiſceatur, facillime dignoſcatur.

29 Hepar Sulphuris cum Auro liquatum illud facile et adeo penitus diſſolvit, ut Aurum una cum Hepate filtrum permeans, in aqua ſuſpenſum maneat.

30 Aurum ab omnibus metallicis ſubſtantiis, Platina excepta, optime purgatur fuſione cum Antimonio; ab omnibus præter Argentum et Platinam cupellatione cum plumbo; ab Argento ſolutione in aqua regia; a Platina et minutis portiunculis cupri aliorumve metallorum quæ Catini ci-

nericii vim haud raro effugiunt, per præcipitationem ab aqua regia interventu vitrioli viridis.

C A P. XV.

De Platina ſive Auro albo.

1 PLATINA eſt metallum perfectum, fixitate, ductilitate, et gravitate ſpecifica auro vix ſecunda; cæteris metallis in igne longe minus fuſilis, et ferro forſan excepto durior; colore argento obfuſcato ſimilis.

2 Platina, in igne vehementiſſimo quem furni et crucibula optima ſuſtinere poſſunt anteaquam in vitrum liqueſcunt, non funditur, ſed pondere aliquantulùm augmentatur: Hæc ponderis augmentatio, adhæſioni forſan ferri vel metalli cujuſlibet imperfecti, quod per calcinationem pondere augetur, referri debet.

3 Platina, radiis ſolaribus condenſatis in foco ſpeculi concavi cujus dia-

meter æqualis erat 22 unciis et focalis diſtantia 28 unciis, expoſita ex parte in fumum erat acta, ex parte fuſa in corpus album, ſplendeſcens, admodum malleabile.

4 Platina non ſolvitur ab acido vitriolico aquoſo aut concentrato, frigido aut ebulliente; nec ab acido marino viâ aut humidâ aut ſiccâ; nec ab acido nitri communi aut fumante; nec a ſulphure communi, nec ab antimonio crudo, et hinc ab omnibus ſubſtantiis metallicis, auro excepto, diſtinguitur.

5 Platina ab aqua regia et hepate ſulphuris, inſtar auri, diſſolvi poteſt.

6 Platina in aqua regia ſoluta eſt coloris aurei, aut fuſci in rubedinem vergentis, prout ſolutio eſt ex parte vel penitus ſaturata: Hæc ſolutio evaporatione concreſcit in cryſtallos rubentes; ſolidis animalium partibus, lamellis vel ſolutioni ſtanni colorem rubrum aut purpureum, lavatione aquæ haud eximendum, non impertit, a ſale ammoniaco ex parte præcipitatur Platina, ſed nec a vitriolo viridi, nec ab

Alkali fixo minerali; ab Oleis-eſſentialibus, Æthere vitriolico, aut Spiritu Vini rectificato a menſtruo ſuo non ſeparatur, et hinc ab ipſo auro diſtinguatur; minimaque hujus vel illius metalli portiuncula, in mixtura quavis metallica ex ambobus conflata, his præcipue ſimilibuſque indicibus faciliime dignoſcatur.

7 Platina ab aqua regia per Alkali volatile præcipitata, exſiccata et igni expoſita non fulminat, et ſic etiam ab auro diſcrepat.

8 Platina a menſtruo ſuo præcipitata, cum vitro contuſo mixta, et igni violentiori per longum tempus expoſita, nec cum vitro fuſione conjungi, nec colorem ullum ei communicare videtur.

9 Platina cum omnibus ſubſtantiis metallicis per fuſionem coit: ſi cum Aurichalci pari pondere fundatur, maſſa conflabitur dura quidem et fragilis, quæ polituram eximiam ſuſcipit, et nitorem ſuum diu conſervat.

10 Platina cum Plumbo aut Biſmutho fuſa, et cupello ſubjecta, igne

vix vehementiſſio ab iſtis metallis, adeo penitus liberari poteſt, ut fiat malleabilis.

11 Aurum cum Platina colliquatum, fit durius et in igne ſimul minus fuſile, quod in mixtione ſua cum aliis metallis non evenit.

12 Mercurius qui majorem habet Affinitatem cum Auro et Argento quam cum Plumbo, habet etiam majorem cum Platina; ſed minorem cum Platina quam cum Auro.

13 Platina majorem habet Affinitatem cum plumbo quam cum ferro.

14 Platina Auri inſtar minorem habet Affinitatem cum aqua regia quam aut Zincum, aut Ferrum, aut Cuprum, aut Stannum, aut Argentum vivum.

FINIS.

Drenned 4/85

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